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Final Report

ARSENIC SOURCE AND WATER SUPPLY REMEDIAL ACTION STUDY

MILLTOWN, MONTANA

Prepared for
Solid Waste Bureau
Montana Department of Health and Environmental Sciences
Helena, Montana

Prepared by

William W. Woessner and Johnnie N. Moore
Carolyn Johns
Marin A. Popoff
Leslie C. Sartor
Mary Lou Sullivan

Department of Geology
University of Montana
Missoula, Montana

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CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are derived from the analysis of sediment and hydrogeologic data presented in this report:

1) The source of metal contamination of the Milltown wells is the sediments in Milltown Reservoir. Water quality and hydraulic gradient data clearly support this conclusion. The reservoir sediments discharge 1,300,000 ft^3/d of water to the unconfined Milltown ground-water system.

2) Ground water with elevated metals and organics associated with well site G, south of the Champion mill appears to be contaminated from a separate localized up-gradient source, unrelated to the reservoir.

3) A well located in the vicinity of wells 106 and C2 will provide required yields and quality for a replacement of the four contaminated Milltown community supply wells. The area is hydrogeologically separated from the contaminated ground water flowing from the reservoir sediments.

4) Sediment in the reservoir contains tens-of-thousands of tons of metals. Total arsenic in the reservoir approximates 1800 tons, 1700 of which is excess above background. Copper is in excess by 14,000 tons and zinc by 27,000 tons. A large percentage of some of these metals is in forms easily extractable, and therefore available to the natural system.

A replacement community well should be located between Rt200 and well site C2 on First Street. Locating the well adjacent to well C2 would allow for cross connection between the two wells. The site is located in the Blackfoot River component of ground-water flow and will easily yield the needed water without impact to existing users. Although the Milltown Reservoir sediments are heavily contaminated with metals, the Blackfoot River

sediments contain only background levels, and will not act as a source of metals to the ground water.

To better understand the chemical and sediment budgets of the reservoir, a detailed surface water monitoring system should be established. Stream discharge, suspended sediment and water quality data should be collected to determine the flow and chemical budgets of the reservoir system. The influence of altering the stage in the reservoir should be assessed by hydraulic modeling of the river system. Because the Milltown reservoir sediments contain a large percentage of fine-grained sediment, a detailed textural study should be done to determine sediment mobility.

The stability of metals in the sediments needs additional geochemical study. Initial indications are that large quantities of metals are readily available to the surface and ground water systems. Flow and solute transport ground-water models should be developed in conjunction with hydraulic modeling and sediment geochemical studies, to evaluate site management alternatives.

ACKNOWLEDGEMENTS

This project represents the combined efforts of many individuals and groups, all of whom wished to have the source of ground-water contamination resolved and a replacement water supply sited. The project was formally supported by a grant from the Montana Department of Health and Environmental Sciences Solid Waste Bureau and the United States Environmental Protection Agency. In addition, the Water Quality Bureau and the Missoula City-County Health Department also provided support for an initial reconnaissance level study. The Missoula county surveyor's office supplied surveying support.

Access to field sampling points was provided by Champion International, Montana Power Company, Montana Department of Highways, Burlington Northern, and the Milltown Water Users Association.

The work of cooperative researchers and contractors was essential for project completion: Camp Well Drilling and Pump Supply; Robert W. Steele-surveyor; Dr. Richard Juday of the Department of Chemistry; Northern Testing Laboratory; Rocky Mountain Laboratory of Denver; Walter H. Ficklin of the Geologic Division of the USGS and Analytical and Isotope labs of the Water Resources Center, Desert Research Institute, Reno and Las Vegas.

Finally, we would like to acknowledge the assistance of the Milltown residents, Champion International Bonner Mill Operation, and the Milltown Water Users Association for their important assistance and support.

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INTRODUCTION

In November, 1981, the Montana Department of Health and Environmental Sciences determined that four community wells in Milltown, Montana, contained ground water with arsenic levels that ranged from 0.22 to 0.51 mg/l. Because arsenic concentrations exceeding 0.05 mg/l in potable water supplies are not recommended by EPA for ingestion, a reconnaisance level hydrogeologic investigation was initiated in February 1982 to examine the potential sources of arsenic contamination (Woessner and Popoff, 1982). The results of that study suggested four possible sources: 1) a wood products mill north of the wells; 2) an abandoned industrial and municipal dump southeast of the wells; 3) an adjacent reservoir containing an unknown quantity of mining and smelting sediments derived from upstream and 4) a deeper bedrock ground-water system underlying the contaminated unconfined aquifer. As the preliminary study was begun, Dr. Moore expressed concern over the reservoir sediments as a potential metal source and so obtained four grab samples of sediment by cutting through the ice in February, 1982. Analyses of samples revealed the sediments contained total metal values ranged from 54 to 135 ppm arsenic, 22,995 to 30,375 ppm iron, 5 to 95 ppm lead, 259 to 1,357 ppm manganese and 66 to 2,880 ppm zinc. As a result of the initial hydrogeologic study and Dr. Moore's, independent work the EPA ranked the Milltown Reservoir as site 200 out of its initial 400 Superfund sites.

The arsenic levels found in the drinking water supply were recognized as a health threat and a Remedial Action Plan was developed for the Milltown site. The authors were asked to prepare a work plan in response to EPA's plan and the project which is the subject of this report was initiated in July

1983.

This report is organized into six sections. For clarity the conclusions and recommendations section is presented first. The second section presents introductory material. The following section discusses the methods used to collect and analyze the field data.. The fourth section presents the results of the hydrogeologic investigation. The fifth section addresses the results of the reservoir sediment study and the last section addresses the location of a new ground-water source. A large portion of the data upon which these descriptions and analyses are based are presented in Appendices.

The introduction section is organized into two additional parts. First the project objectives and a description of the basic data necessary to accomplish them are presented. Then the introduction describes the general study area's physiography, climate, geology, and hydrology.

PROJECT OBJECTIVES

The objectives of the project were two-fold: 1) Identification of the source of arsenic contaminating wells in Milltown; 2) Location of a site for a new water supply. Identifying the source of arsenic in the ground water required a two- pronged approach. A detailed study of the aquifer underlying Milltown was needed to determine the extent of the contamination and the direction and rates of ground-water flow. In conjunction with the hydrogeologic effort, a detailed evaluation of the geochemistry of the sediments in the Milltown reservoir Superfund site was initiated. The previous sediment sampling had identified the reservoir as containing As and other metals at levels greater than background values. Because of this data and results of the initial hydrogeologic study which suggested a large hydraulic gradient was present from the reservoir to the affected wells, the

sediments were suspected to be one of the sources of ground-water contamination. With the ground-water system delineated and the source or sources of contamination identified, the potential for an uncontaminated ground-water supply to replace the affected one could be evaluated.

SITE DESCRIPTION

This section is intended to provide the reader with a brief overview of the study area. It describes the physiography, climate, geology, and hydrology.

PHYSIOGRAPHY

Milltown Valley lies along a northwest-trending section of the Clark Fork River five miles east of Missoula, Montana (Figure 1.1). The valley ranges from three-quarters to one mile in width and stretches about one and one-half miles upstream from Milltown Dam. The Milltown Reservoir, south of Milltown, is formed behind Milltown Dam at the confluence of the Clark Fork and Blackfoot rivers. The valley separates 5,806 feet high Mount Sentinel southwest of the reservoir from 6,813 feet high Bonner Mountain and the Garnet Range located to the northeast. The towns of Milltown and Bonner are the main population centers in the study area and Champion International operates a plywood and stud mill immediately north of Milltown (Figure 1.2).

CLIMATE

The study area has a semi-arid climate with an average annual precipitaion of 13 inches. May and June are the wettest months and March the driest. Temperatures average 22.7° F during January, the coldest month, and

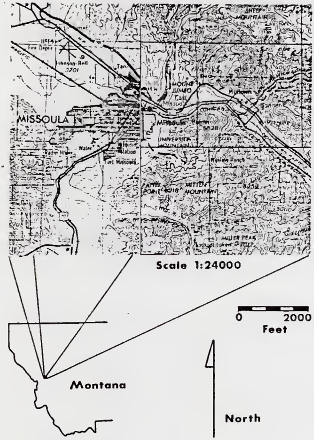


Figure 1.1: Location map of Milltown, Montana and vicinity.

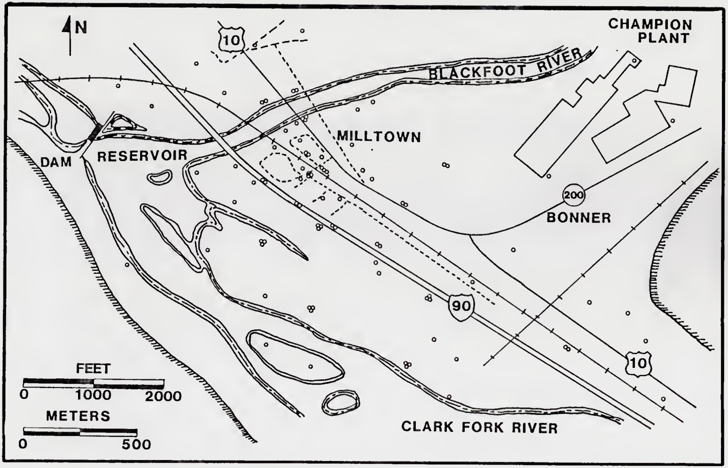


Figure 1.2: Location of well sites in Milltown. Includes residential and commercial wells, projects wells, and sandpoints.

71.8° F during July, the warmest month. In January or February subarctic air from Canada occasionally spills over the continental divide 55 miles to the northeast and sweeps through the valley, bringing sub-zero temperatures. For much of the year moist Pacific air dominates the climate.

GEOLOGY

The study area is underlain by deposits of Quaternary alluvium and Precambrian metasediments (Figure 1.3). Valley alluvium consists of interbedded sand, gravel and boulders with some clay lenses. Analysis of well drillers'geologic logs indicates that sediments generally thicken north of the reservoir and reach a depth of 155 feet within the southern boundaries of the Champion mill site. The thickness of the Recent reservoir sediments are estimated at 29 feet based on dam height.

Precambrian metasediments of the Belt Series lie under the valley alluvium. Argillite, quartzite and limestone crop out on Mount Sentinel, Bonner Mountain and Sheep Mountain located northwest of Milltown and northwest of the Blackfoot River. Several diabase sills and dikes intrude the metamorphosed sediments along the argillite-quartzite contact near the dam and on the slopes of Sheep Mountain.

Structurally, the study area is complex. The metasediments north and east of the Clark Fork River are folded as the Bonner Mountain anticline, which is overturned west of Bonner and north of Milltown. Locally, a syncline of quartzite on Mount Sentinel plunges towards the reservoir. The Clark Fork Shear Zone and the Sapphire Thrust System further complicate the structure in this area. The Blackfoot thrust crops out on Bonner Mountain and parallels the Blackfoot River into the Clark Fork Fault. Wallace (1980) re-defined the argillite and quartzite units in this area as Mount Shields Formation and Bonner Mountain Member, respectively, and subsequently mapped a thrust fault

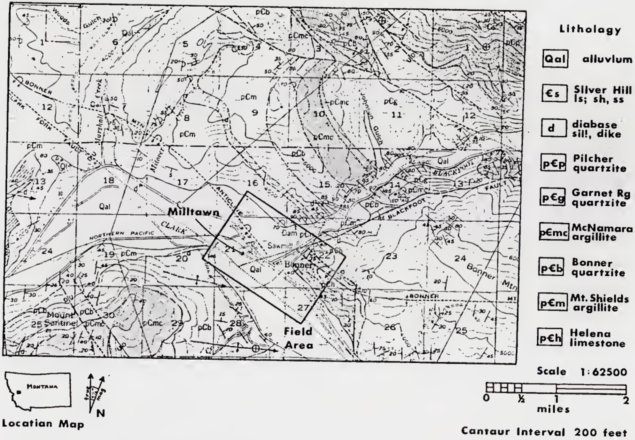


Figure 1.3: Geologic map of Milltown valley and vicinity. (after Nelson and Dobell, 1961; Wallace quad., unpubl.)

along their contact on the north slope of Mount Sentinel. The thrust fault strikes into the north slope of Mount Sentinel and into the Clark Fork Shear Zone at Milltown Dam, and presumably is offset northwestward from the Blackfoot thrust by the Clark Fork Fault.

HYDROLOGY

Milltown is located at the confluence of the Blackfoot and Clark Fork rivers. Discharge records for the Blackfoot River are obtained from USGS station 123400000 located eight miles north of Milltown. The average annual flow based on 46 years of record from the 2,290 mi^2 drainage basin is 1,658 ft^3/s. The maximum discharge was recorded on June 10, 1964 at 19,200 ft^3/s and the mininum daily flow was 200 ft^3/s on January 4 and 5, 1950. The discharge records for the Clark Fork River are obtained from USGS station 123405000 located 2.8 miles below Milltown Dam. Based on 53 years of record the 5,999 mi^2 drainage basin yields an average annual discharge of 3,055 ft^3/s. The maximum discharge for the period of record was 32,300 ft^3/s recorded on June 21, 1975. The gage was not in operation during the 1908 flood which was estimated to have a discharge of 51,000 ft^3/s at Missoula about five miles downstream from the dam. The minimum daily flow is 340 ft^3/s and was recorded on September 27, 1937.

Milltown Dam was constructed in 1907. However, during the 1908 flood a section of the dam was blown out in an attempt to save the structure. The dam was repaired and has been in continual operation since 1908. The discharge records for the Clark Fork River described above indicate that 2.1×10^6 acre/feet of water flows over the dam annually. Of that discharge the Clark Fork River and Blackfoot River discharges are 46% and 54% of the total, respectively.

The principal ground-water system in the study area is the valley

alluvial aquifer. A soil mantle and fractured bedrock ground-water system occur in the mountainous areas, however, it appears that it comprises only a minor portion of the area ground-water system. The valley fill unconfined aquifer is composed of well-sorted sand, gravel and boulders. The aquifer thickens from 40 ft near the reservoir to over 100 ft north of Milltown in the southern boundary of the Champion mill property. The general direction of flow is parallel to the Blackfoot River and the Clark Fork River. These two flow systems and a possible flow component from the reservoir meet in Milltown and flow westward to discharge into the Clark Fork River below the dam. The system is recharged by the Clark Fork and Blackfoot rivers just above the reservoir and by the reservoir itself. The transmissivity calculated from information on well drillers logs range from 170 ft^2/d to 13,000 ft^2/d (Woessner and Popoff, 1982). Based on available pre-project data, ground-water velocities range from 0.17 to 2.0 ft/d.

METHODOLOGY

The methodology section is organized into five principal sections: 1) site hydrogeology; 2) sediment sampling; 3) laboratory techniques; 4) project quality control and 5) statistical analyses. The first two sections describe the data needs and project design in addition to the field methods and sampling schemes selected for data collection. The third section addresses the specific project geochemical laboratory methods and general contract laboratory methods for water, sediment and soil sample analysis. The fourth section describes project quality control. The fifth section presents the statistical methods used to evaluate the data.

HYDROGEOLOGY

The overall hydrogeologic evaluation of the Milltown area was designed to expand on the data base derived from the earlier reconaissance level study (Woessner and Popoff, 1982). That study identified the extent of apparent ground-water contamination and the complex flow system based on monitoring existing wells for head and ground-water quality. It also proposed four possible sources of the contamination: 1) a wood products mill; 2) an abandoned dump; 3) the reservoir sediments and 4) the underlying bedrock ground-water system. In addition to the initial study, geochemical analyses of four grab samples of the reservoir sediments and a water quality analysis from a well constructed between the reservoir and Milltown which showed the highest levels of arsenic and other metals recorded in the ground water were available prior to the initiation of this project. Ground-water head data also were available from two continuous recorders operated since February 1982 by Marin Popoff of the University of Montana as part of his master's research.

Based on the available information it was decided to expand the 51 well monitoring network with additional sampling points to better characterize the geologic composition and geometry of the unconsolidated aquifer and underlying bedrock. The drilling program would also be used to determine the extent of the ground-water contamination and the ground-water chemistry of the bedrock, to define the ground-water flow patterns and to gather aquifer parameter information at sites which appeared to be possible locations for a new community water supply well. All data collection methods focused on determining the source or sources of metals and the paths of transport, and locating a community supply well which would not become contaminated by the source or sources of metals. The following material is presented in two sections: the first deals with the design and construction of the monitoring well network and the second section addresses hydrologic data collection and analysis.

MONITORING WELL DESIGN AND CONSTRUCTION

The design of the monitoring well construction program was based on the data needs described above. However, initial review of the available data indicated that for data generation to be maximized and drilling sites minimized a more detailed information on the bedrock topography and the overlying unconsolidated unconfined aquifer were required. As a result, a geophysical study was initiated. The study was under a time constraint of approximately two weeks as the initial drilling program was planned to begin in late July to early August. Three geophysical survey techniques were attempted to principally determine depth to bedrock: 1) gravity; 2) electrical resistivity and 3) seismic refraction. Standard techniques were utilized and the details of the methods and results of the three survey techniques are presented in Appendix A.

A 12 site drilling project (site numbers 100 to 111) was designed using

seismic depth to bedrock, drillers' geologic logs and hydrogeologic setting data determined previously (Figure 2.1). At the completion of the drilling program a 13th site, 99, was added to determine if a seismically interpreted bedrock barrier to flow was present between contaminated wells in Milltown and nearby uncontaminated wells. At each site, the subcontractor, Camp Well Drilling and Pump Supply, used an air rotary drilling rig equipped with a casing hammer to drill and drive steel casing to prescribed depths. Construction began in mid -September and was completed by mid-December of 1983. Drill cuttings were described and logged at five feet intervals or changes in lithology. Samples were placed in plastic bags and boxed for storage. When the water table was encountered, samples of the water blown from the hole were collected, filtered and preserved for gross chemistry and metal analyses. These samples were taken at 20 to 40 ft intervals. Once steel casing was in place, PVC flush-coupled four inch or two inch diameter pipe with five feet of 0.020 inch mill slotted PVC well screen was installed to the desired depth and then gravel-packed; the steel casing was removed by jacking. Bentonite pellets were used to hydrogeologically isolate deeper screened intervals from the disturbed borehole. The basic well design is shown in Figure 2.2.

At sites 99, 100, 101A and 111 one hole was drilled. At the rest of the sites two steel casing holes were constructed. Final well completion data are presented in Appendix B. The first hole was always drilled into bedrock about 20 ft to ensure we were not in a boulder. Based on the overlying thickness of saturated alluvium and interpretation of data from a gamma ray geophysical bore hole log (produced by a Johnson-Keck GR-81 logger) one well was completed just above the bedrock-alluvium contact and a second well was either completed in the first steel casing or a second steel casing was drilled to the desired

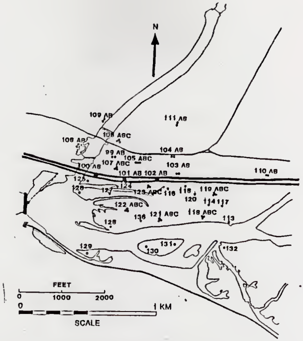


Figure 2.1a: Location of project wells.

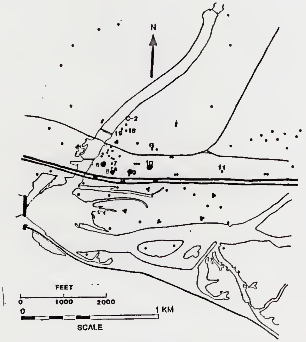


Figure 2.1b: Complete monitoring well network. Contaminated community wells are represented by large solid dots.

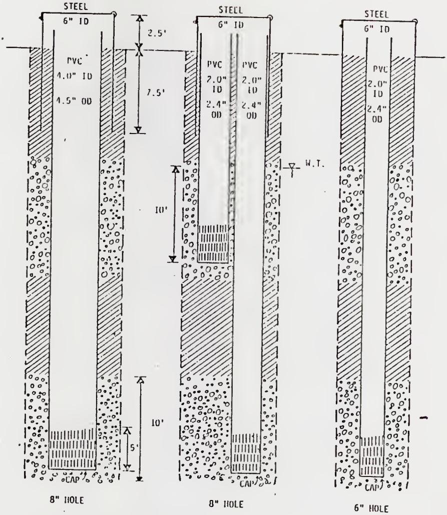


Figure 2.2: Basic well design.

depth. At sites which contain two wells, numbered A and B, the second PVC well was finished about 10 ft below the water table. At sites that have three wells numbered A, B and C, the alluvium was thicker and a third well was placed at a depth between the water table and bedrock at an interval interpreted to be a change in the geology or at a depth close to the midpoint between the depths of the other two wells. At sites 100A, 104A and 107B, wells were completed about 10 ft below the bedrock-alluvium contact. Monitoring well nests were constructed at each site in order to collect data on the vertical distribution of head and chemical constituents. Because the drilling contractor had one crew drilling and installing the steel casing and another crew to set the PVC and pull back the steel, we decided to conduct aquifer tests before PVC installation, using the eight inch diameter wells drilled to depths which did not penetrate the bedrock. A description of the testing techniques will be presented in the following section.

In addition to the 26 well network constructed by the contractor, project personnel installed 30 PVC sandpoint wells in the reservoir sediment during November 1983. Wells were constructed with 1.25 inch PVC schedule 40 pipe. Single wells were equipped with a mill-slotted 0.010 inch well screen three feet in length, while piezometer or well nests of three wells each constructed to depths of about 5, 12 and 15 ft were equiped with similar screens of one foot in length. Wells were installed by hand augering individual holes to within one foot of the desired depth and then driving the assembled well to the design depth by using a hand operated fence post driver. Details of well construction are presented in Appendix B.

HYDROGEOLOGIC DATA COLLECTION AND ANALYSES

The hydrogeologic data collected for the study site and the analyses of the data were directed towards evaluating the ground-water flow system,

identifying the source or sources of contamination and locating a community supply well. In order to identify the source of contamination, the natural occurrence, movement, quantity and quality of ground water in the study area was determined. Data collection was first directed at understanding the natural system and then used to examine the potential sources of contamination as they relate to the natural system and a new community water supply. The final part of this section presents the methods used to examine the acetic acid extractable As concentrations in the surface soils in the study area. This program was primarily implemented to determine if the source of ground-water contamination resulted from a surface spill.

Occurrence and Movement

The physical frame work within which the alluvial ground-water system operates was derived from well drillers' reports, seismic data collected at 17 points and descriptions of drill cuttings at 13 sites. Isopach maps of the unconsolidated aquifer and saturated aquifer thickness were prepared, as were geologic cross sections.

The position of the water table was determined by measuring the water level in wells with a steel or electric tape. The elevation of the water table was then determined by surveying the MSL elevation of the points of measurement and then substracting the depth to water. Wells 8 and G were measured since march 1982 with a Stevens Type F continuous water level recorders equipped with monthly clocks. At the initiation of the project, water levels in 32 wells were measured in August, 1983; water levels in 76 wells were monitored in late November-early December, 1983. In January, 1984, a water level program was initiated to monitor 20 wells monthly until June, 1984, and 34 wells quarterly, in March and June (Figures 2.3 and 2.4). Water level data collected from February, 1982, through June, 1984, was used to assess the hydrogeologic setting.

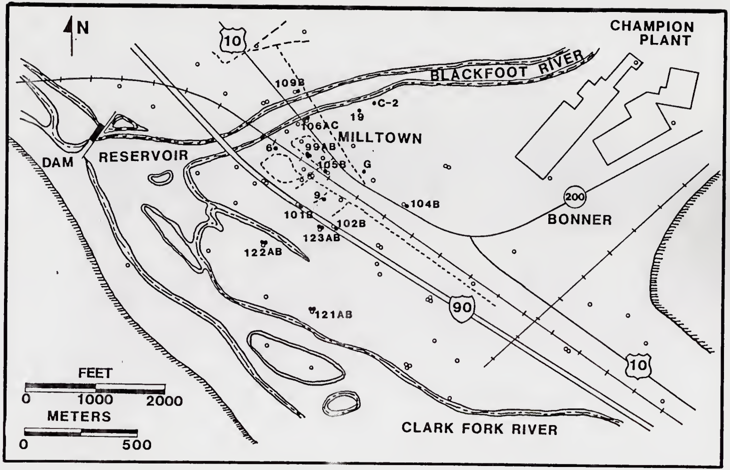


Figure 2.3: Location of quarterly water sampling and water level monitoring sites.

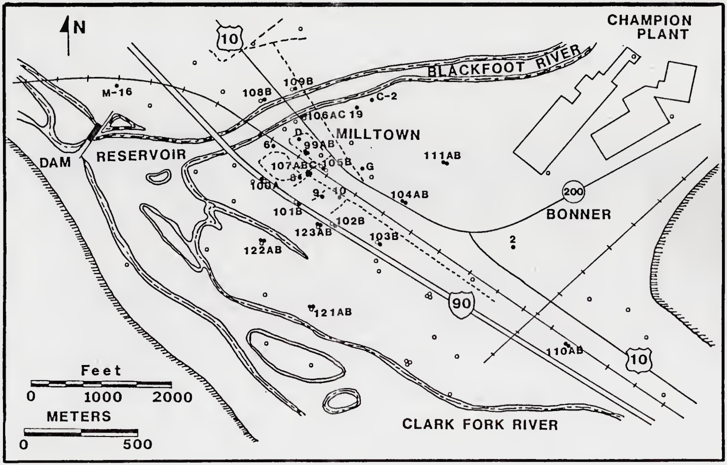


Figure 2.4: Location of monthly water sampling and water level monitoring sites.

In an attempt to assess the causes of fluctuations seen at the observation wells, hydrographs of reservoir stage and the discharges of the Blackfoot River and Clark Fork River were constructed from data supplied by Montana Power Company and the USGS. These data were overlain with well hydrographs for visual comparison and were also statistically evaluated for linear correlations.

The direction of ground-water movement was determined by constructing a contour map of the hydraulic head data for the shallow wells which penetrate the upper part of the aquifer. The direction of ground-water flow was then determined by constructing flow lines which cross the lines of equal head (equipotential lines) at right angles. The direction of ground-water flow is in the direction of decreasing head. This method assumes the aquifer is isotropic and homogeneous in hydrogeologic character and that flow also principally occurs in the horizontal plane. These assumptions generally are valid only if shallow wells are used and the aquifer material is fairly uniform. In the Milltown area the fluvial depositional environment yields coarse grained stream channels mixed with slightly finer grained material; however, the degree of heterogeneity and anisotropy of the aquifer can not be determined at the level of this study. Vertical gradients at well nests were also evaluated to determine the degree to which upward or downward gradients existed in the bedrock and alluvial material.

Aquifer tests were conducted to determine the transmissivity and hydraulic conductivity at eight locations 102B, 103B, 105B, 106B, 107B, 108B, 109B, and 110B. Step drawdown, multi-rate constant discharge and constant discharge tests were conducted on open-ended eight inch diameter casing that penetrated the mid-section of the aquifer. Tests were completed prior to PVC installation. Test procedures and results are presented in Appendix C. These

values were combined with horizontal hydraulic gradients derived from potentiometric maps, and ground-water velocities were calculated for areas of the study area using:

$$v = \frac{K\,dh}{n\,dl}$$

where:

v = ground-water velocity, ft/d
K = hydraulic conductivity, ft/d
$\frac{dh}{dl}$ = hydraulic gradient, dimentionless
n = porosity, estimated to be .25

Aquifer property data were also used to calculate the hydraulic effects that a new community well would have on the flow system and the effects that discontinuing production from the existing wells would have on the distribution of flow.

Water Quality Sampling

Samples of ground water and surface water were obtained to characterize the water quality of the alluvium, bedrock and river systems. The data were used to evaluate if water chemistry varied over time, to identify possible sources of contamination and to identify components of ground-water flow. Water quality sampling included general gross chemistry and metal chemistry, and specialty water chemistry. The following material will discuss the general sampling procedures and those for the specialty chemistry.

The gross chemistry analysis included the determination of chloride, sulfate, bicarbonate, calcium, magnesium, sodium, potassium, total dissolved solids, and pH. The analyses were performed by Dr. Richard Juday of the Department of Chemistry at the University of Montana. The metal analysis included determination of arsenic, iron, manganeses, zinc, lead, copper, cadmium and nickel. Analyses were performed by the Gordon Environmental Studies Lab at the University of Montana and Rocky Mountain Lab of Denver.

. Water quality samples were collected from individual domestic wells and community wells using taps at homes receiving water from those sources. Direct access to the water before it passed through the holding tank and pipes was not possible. Samples from wells not equipped with a pump were obtained by using a portable Johnson-Keck SP-81 Submersible Sampling Pump. Samples from well G were obtained by PVC bailer prior to July, 1984 and then by portable pump. Well 104A was also bailed to obtain a sample because an obstruction in the well bore prevented the use of the pump. Samples of surface water were taken with a plastic bucket.

Water samples collected during the previous study (Woessner and Popoff, 1982) and the approximately 100 samples collected by Marin Popoff from April 1983 until June 1983 were collected from household taps after allowing the water to run for about 3 to 5 minutes. Samples were filtered using an in-line 142 mm Geofilter directly attached to the faucet and piped into plastic one-quart cubic containers, cubitainers, which had been rinsed three times with the filtered sample. The samples for metal analysis were immediately acidified with 3 ml of concentrated reagent grade nitric acid. Samples for gross chemistry analyses collected as part of the previous reconnaissance study were filtered, placed in sample-rinsed bottles and delivered to the lab for analysis. At the initiation of this study, all water samples taken from household taps, obtained with the portable submersible pump or peristaltic Black and Decker "Jack Rabbit" pump, or bailed from wells were filtered with the Geofilter 142 mm in-line filter after the sample specific conductance and temperature had stablized. Samples collected for metal analysis were immediately placed in acid-washed, and deionized water-rinsed and sample water-rinsed cubitainers then acidified to a pH of <2 with 3 ml of concentrated nitric acid. Samples collected for standard gross chemistry analysis were passed through the filter and piped into clean sample-washed

cubitainers and refrigerated to 4^oC in the field and in storage before delivery to the lab for analysis. Samples of surface water and those collected during drilling were first collected in a plastic bucket rinsed with the sample, and then poured into a 2.5 l Geofilter barrel filter and purged with nitrogen gas into sample-rinsed acid-washed containers for metal analyses and clean sample-rinsed containers for gross chemistry. Preservation of these samples was similar to that for the pumped samples. Temperature, pH and specific conductance were measured in the field on unfiltered and untreated samples at each sampling site. An Orion 399A pH meter was used to measure pH and a YSI 33M meter was used to determine temperature and specific conductance.

Beginning February, 1983, Marin Popoff sampled wells 6, 7, 8, 9 and 10 monthly and then weekly from mid-April through July, 1983, for metal analysis: As, Mn, Fe, and Zn. Samples were also collected for metal analysis in January, March-early April, May, and July at 8 additional sites. During the first sampling run of this project, 42 of the wells in the area were sampled for gross chemistry and complete metal analyses in August, 1983. This survey was intended to check data from the earlier hydrogeologic study and establish a base from which to further evaluate the planned location of monitoring wells. Fifteen selected wells were sampled for metal chemistry in September and October and then a comprehensive sampling was completed for gross chemistry and metal chemistry in late November and early December, 1983 at 25 new project wells and 11 selected existing wells. From January through June, 1984, monthly samples for As, Fe, Mn, and Zn were collected from wells shown in Figure 2.3, and quarterly samples were collected for gross chemistry and the same monthly suite of metals at the sites shown in Figure 2.4. The exact dates and types of analyses performed at each well are presented in Appendix

D.

One-time sampling for tritium, stable isotopes of deuterium and ^{18}O fluoride, nitrate, antimony, mercury, selenium, total organic carbon, and arsenic speciation, and two groups of sampling for tannin- and lignin-like substances were performed to evaluate the levels of these constituents at sites selected to characterize surface-water and ground-water systems in the study area. Appendix D also contains the well numbers, dates and results of these sampling efforts. The sampling procedure and rationale for the evaluation of these constituents follows.

At eight sites prior to project well construction, tritium samples were collected to evaluate the relative age of surface water and ground water present in the alluvium and bedrock. Samples were taken from taps after temperature and specific conductance stablized. Water from a tap was run into a rinsed plastic bucket; then, dry 32 oz glass bottles were submerged and capped under water in an attempt to exclude air. The sample for the surface water was taken with a rinsed plastic bucket and bottled as described above. The tops of the bottles were then wrapped with Parafilm and black electrical tape. Samples were mailed to the Water Resources Lab of the Desert Research Institute, Reno, Nevada for analysis.

Thirteen water samples were collected and analyzed for deuterium and $^{18}O/^{16}O$ analyzed to determine if surface water, alluvium ground water and bedrock ground water had different stable isotope signatures. Samples were collected in clean dry 60 ml glass bottles using the same techniques as described for tritium. Bottles were sent to the Stable Isotope Lab of the Desert Research Institute in Las Vegas, Nevada, for analysis.

Thirty seven samples for fluoride and 14 samples for nitrate analysis were collected in January, 1984. These samples were taken to evaluate if

nitrates or fluorides exceeded drinking water standards and, in the case of nitrates, to evaluate the presence or absence of septic system wastes in the ground-water system. Unfiltered samples were collected from wells after temperature and specific conductance stablized. Samples were refrigerated and delivered to Dr. Juday at the Department of Chemistry, University of Montana, for analysis within the required holding times.

Mercury and selenium analyses were performed on 12 samples to determine if additional analyses were necessary on more wells. Metal sampling and perservation techniques were utilized and samples were sent to Northern Testing Lab in Billings for analysis. Twenty antimony samples were collected in March, 1984, filtered, and preserved with 0.5 ml of 0.12M hydrochloric acid. Samples were analyzed by W. H. Ficklin at the USGS in Denver.

Arsenic speciation analyses were performed on 20 samples collected in April and May, 1984. Fifty-milliliter samples were filtered and preserved with 0.5 ml of concentrated hydrochloric acid. These samples were evaluated to determine the oxidation state of inorganic arsenic species. The twenty antimony samples collected at the same locations in March, 1984, were evaluated for dimethylarsenite. All analyses were performed by W.H. Ficklin of the USGS in Denver.

Total dissolved organic carbon was determined for 19 samples collected in May, 1984. These analyses were used in combination with tannin and lignin analyses to determine the distribution of general organics in the ground-water system. Samples were collected in 500 ml plastic containers and preserved with 2 ml of concentrated sulfuric acid. Analyses were performed by Rocky Mountain Lab in Denver.

Two sets of sampling for tannin- and lignin-like substances were performed. These analyses were also used to evaluate the general presence of organics in the ground-water system. Thirty four samples were collected in

October, 1983, and 21 samples in February, 1984. Unfiltered samples were collected in plastic bottles. Analyses were performed by Northern Testing Lab in Billings. Sampling site locations and results of analyses performed in 1975 and 1982 are also presented in Appendix D.

Soil Sampling

A program was designed to evaluate whether the source of ground-water contamination could be a result of land surface contamination. Sample locations were selected to examine the surficial distribution of arsenic in the study area (Figure 2.5). Sample collection focused on the area with contaminated wells, the land adjacent to the railroad tracks, the Champion mill property, the soil developed on the reservoir sediments south of Milltown, and the sites which appeared to be possible locations for a new water supply. In addition, several gardens in the area of the contaminated wells were sampled. For comparison, soils from one garden in West Riverside and two gardens in Missoula were also sampled.

The soil corer used was a JMC Back-Saver Handle with a JMC "O" Contamination Tube designed to allow insertion of a 0.90 inch diameter, rigid, acetate, liner tube. This method minimized possible contamination from the corer because soil cores contacted metal only at the tip of the corer. Before sampling, the acetate liner tubes were acid-washed and then rinsed three times with distilled, deionized water and allowed to air dry. The tubes remained capped until insertion into the corer. Before each sample the corer tube was washed with deionized water, scrubbed with a brush to remove soil particles (especially around the corer tip), and again rinsed with deionized water. Because wet acetate tubes tended to stick inside the metal corer, the corer tube was rinsed with acetone to remove any remaining water droplets and then air dried.

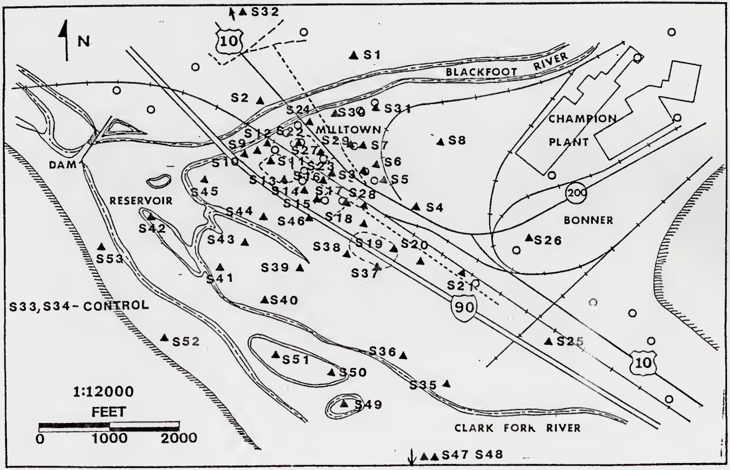


Figure 2.5: Location of surface soil sampling sites.

At each soil sample site a clean acetate liner was inserted into the clean soil corer. Four short soil cores (2 to 6 cm, depending on soil compaction) were taken, one from each side of a 32 inch outside diameter plastic circular template. The template was marked at $90^{o}C$ intervals and oriented on the ground so that one core was taken on the northern, southern, eastern, and western points. All four cores were composited in one acetate tube. After the four cores were taken, the acetate liner was removed from the corer and the ends of the tube capped. Each tube was numbered on its side. At each sample site sample number, date, location, and samplers were recorded. Soil sample locations were marked on a map of Milltown and the reservoir area. Capped acetate tubes were transported back to the laboratory and refrigerated until further processing.

SEDIMENT SAMPLING

The overall objective of sampling in the reservoir was to evaluate the accumulated sediment as a possible source of arsenic in ground-water contaminated wells in adjacent Milltown. Grab samples were collected to assess the lateral distribution of metals in sediment throughout the reservoir. Sediment cores were used to characterize vertical changes in the geochemistry of the sediments at selected sites.

Grab samples were collected using a Peterson grab sampler at 34 sites throughout the reservoir in both the Blackfoot and ClarkFork portions (Figure 4.4) where finer grained sediments were deposited. Grabs sampled the uppermost 15 to 20 cm of sediment. Each grab site was marked on a field map of the reservoir and later marked on a permanent map kept in the office. Information recorded on field sheets for each grab included date, time, location, depth to sediment, sample number, sampling personnel, plus other comments, if any. When the grab sampler was opened, the outer layer of sediment which had been in

contact with the metal walls of the sampler was discarded. Using an acid-rinsed, then deionized water rinsed rubber spatula, the sediment was scooped from the central portion of the grab sampler to fill a plastic container which had been previously acid-washed. Once full, the numbered container was stored in an ice chest for transport to the laboratory.

Immediately upon return to the laboratory, pH and temperature were measured on each grab sample. A subsample of sediment was split off for later grain size analysis and stored in a plastic, snap-cap vial. Pore water was extracted by centrifugation of the sediment. After pore water extraction, thesediment was dried, ground, and extracted with acetic acid. The residue of this extraction and/or another subsample from the original grab sample was used to determine the residual and/or total fraction of metals in the sediment. This three-step extraction procedure allowed determination of metals in the pore water which are essentially easily available to natural systems at the present physical and chemical conditions. The acetic acid extraction identified metals tied to iron and manganese oxides and hydoxides, carbonates, and those easily released from clays and organic compounds. The residual/total digestion allowed determination of the metals tightly bound in either mineral lattices or resistant compounds.

Based on arsenic and other metal concentrations in the acetic acid extractions from the grab samples, cores were taken at six sites to examine spacial and temporal variations in metal content both in areas of high metal concentrations and those of lesser concentrations. One core was taken from a small slough off the Blackfoot arm of the reservoir. Three core sites were located along the northern edge of the reservoir as close to the contaminated wells as possible.

At each coring site two cores were taken, one for stratigraphic

description and one for metal analyses. First, a solid (unsectioned) core tube was emplaced by hand to a maximum of 1.5 meters to check penetration and to take the core to describe the stratigraphy at the site. The stratigraphy core was kept intact in the core tube and transported to the laboratory where it was split lengthwise and described. Some samples were taken from the stratigraphy core for more detailed examination of particle size and for X-ray diffraction work.

The geochemistry core was taken as close to the stratigraphy core as possible so that the stratigraphy could be compared to the sediment geochemistry. The core tube was again emplaced by hand. The tube was left open at the top to minimize sediment disturbance and then capped by hand before retrieval. The 5.4 cm (inside diameter) core tube was precut into 10 cm long sections which were labelled and placed sequentially into an outer PVC coring tube with a 6 cm outside didameter. When the core device was extracted from the sediment, the core sections were sliced through with monofilament. The ends of the sections were immediately capped to protect the core section from the oxidizing atmosphere. Each section was placed in a labelled, clean, plastic container and kept in ice for transport to the laboratory. To prevent contamination, the core tube sections were acid washed before transport to the field and kept sealed in the acid-washed plastic containers until use.

Analytical procedures, sediment.

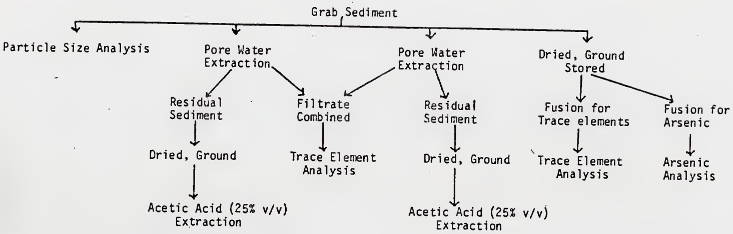


Figure 2.6

Flow chart for analysis of grab samples

LABORATORY TECHNIQUES

GRAB SAMPLES

The approximately one liter of sediment collected by grab sampling was used for several analyses. The procedure described below was followed for all grab samples (Figure 2.6):

(1) A portion of the sample was separated into a labelled, acid-washed, snap-cap plastic vial for particle size analysis. Grain size analysis was conducted using standard seiving and pipet analyses to determine percent sand, ilt, and clay (Twenhofel and Tyler, 1941; Sullivan and Jacobsen, 1958). First a subsample was dried at 70 °C and weighed to the nearest .1mg. Then the sample was wet seived through a 63 micron screen, and the remaining sand fraction dried and weighed. Wet seiving utilized dispersant composed of 5 grams calgon per liter of water. The fine fraction was transferred to a 1000 ml graduated cylinder. The column was stirred and left to set for 60 seconds. Then a 20 ml aliquot was taken at a depth of 20 cm and transferred to a pre-weighed beaker. The dried residue was weighed and this (after accounting for the weight of the dispersant) represented the silt fraction - between 63 and 4 microns. Another 20 ml aliquot was taken at a depth of 10 cm after 3 hours and 11 minutes. The dry weight of this aliquot represented the clay fraction (<4 microns).

(2) Another subsample was taken directly from the grab sample and placed in an acid-washed beaker. This sample was also dried at 70 °C, ground in a diamonite mortar and pestle and stored in a plastic, snap-cap vial. This fraction was used for determination of total iron, zinc, and manganese by lithium metaborate fusion-dissolution method (Shapiro, 1977; Cantillo, et al., 1984). For the fusion a 0.5 gram sample was mixed with 2.5 grams of lithium

metaborate in a carbon crucible. The carbon crucible was placed in a muffle furnace at 1000°C for twenty minutes. The resulting melt was poured directly into teflon beaker containing 10 ml of concentrated nitric acid in approximately 50 ml of deionized water. Upon contact with the diluted acid, the melt shattered and cooled into small pieces which rapidly dissolved with stirring. Sometimes a black insoluble phase formed when samples which had higher clay or organic contents were fused. These samples were rerun until the black insoluble phase either did not appear or constituted less than 5% of the original sediment sample volume. The solution was quantitatively transferred from the beaker to a Whatman filtration apparatus and filtered through a 0.45 micron millipore filter. The filtrate was quantitatively transferred from to a 250 ml volumetric flask and made to final volume with deionized water. Final solutions were sotred in polyethylene bottles until analysis. Cantillo and others (1984) demonstrated that samples storage up to 10 months had no siginificant effect on measured metal concentrations.

Preliminary analyses showed low to poor recovery of lead, cadmium, and copper. Lead and cadmium recoveries were probably low due to the relatively low concentrations in the sediment. Copper recoveries may have been lower due to difficulty in fusing samples with higher clay and/or organic contents (J. Standish, Energy Laboratories, Inc., personal communication, 1984). Also, the method we originally proposed to use for arsenic (Plumb, 1981) in the sediment samples proved to show poor and highly variable arsenic recoveries. Consequently, we decided to use a hot aqua regia digestion described below.

Another fraction of the subsample was digested with aqua regia (3HCl:1HNO3)(Forstner and Wittman, 1981). For this digestion approximately .75 to .82 grams of dried sediment was weighed into a clean erlenmeyer flask and 15 ml of aqua regia added. After swirling the flask contents, the flask was

placed on a hot plate under the hood. Two additons of 10 ml aqua regia were made when acid volume in the flask was reduced to approximately 4-5 ml. After 4 hours of heating the final acid volume was reduced to 2 ml. The sediment in the flask was never allowed to go to dryness. The flask was removed from the heat and 20 ml of deionized, distilled water added. This solution was quantitatively transferred to a Whatman filter apparatus and filtered through a 0.45 micron millipore filter. The filtrate was then quantitatively transferred to a 100 ml volumetric flask and made to final volume with additional deionized, distilled water. This extract was analyzed for arsenic, cadmium, copper, and lead. Sediment from one grab sample was used in a series of digestions using the same 25 ml total volume of aqua regia but ranging the digestion times from 1 to 5 hours at one hour increments. These digestions were performed in triplicate. Results of these analyses are reported in the quality control section and Appendix F.

A third fraction of this subsample was removed for analysis of carbon content. To remove the inorganic carbon fraction, approximately 1.5 grams of sediment were treated with 10% HCl (Hobbs, 1983) Small additions of HCl continued until the sample ceased fizzing. The dilute HCl was evaporated off at 70oC and the sample repowdered. These samples were stored in snap-cap plastic vials for shipment to Western Analytical Lab, Inc. in Salt Lake City for carbon analysis using a LECO furnace and carbon analyzer.

(3) Two other subsamples were taken from the grab sample and run through the first two steps of a three-step extraction sequence similar to the scheme developed by Chester and Hughes (1967), Gupta and Chen (1975) and Skei and Paus (1979). In the first of these steps, pore water was extracted from the sediment by centrifugation for 20 minutes at 1500 rpm in sealed 250 ml polycarbonate centrifuge tubes. The supernatant pore water from each tube of each pair was decanted and combined in a Whatman filtration apparatus and

filtered through a 0.45 micron millipore filter to remove small suspended solids. The filtrate was acidified to approximately pH 2 with "Instra-Analyzed" nitric acid and refrigerated in labelled polyethylene bottles until analysis for arsenic, cadmium, copper, iron, lead, manganese, nickel, and zinc.

For the second step, the residual sediment was placed in clean beakers, dried at 70°C and ground with a diamonite mortar and pestle. Sediment from this fraction was extracted with 25% "Instra-Analzed" acetic acid (v/v) by shaking 4 grams of sediment with 80 ml of acid for 12 hours in 250 ml polycarbonate centrifuge tubes. After shaking, the tubes were centrifuged for 20 minutes at 1500 rpm. The supernatant was decanted into the filtration set-up and filtered through a 0.45 micron millipore filter. This filtrate was analyzed for arsenic, cadmium, copper, iron, lead, manganese, nickel, and zinc. Acetic acid extractions were run on the duplicate subsamples used for pore water extraction. Metals values were averaged.

The third step of the extraction scheme consisted of the aqua regia digestion and lithium metaborate fusion-dissolution described above.

CORE SAMPLES

Geochemistry core sections were basically analyzed with the same methods used for the grab samples with the exception of the technique used for pore water extraction (Figure 2.7).

For extracting pore water, a sealed core section was unsealed and placed in the gas displacement-filtration unit. This unit is designed so that the core tube section containing sediment is completely enclosed except for the inlet for nitrogen gas at the top and exit for the pore water to drip into the filtering apparatus at the bottom. Once the core section was in place,

Analytical procedures, cores.

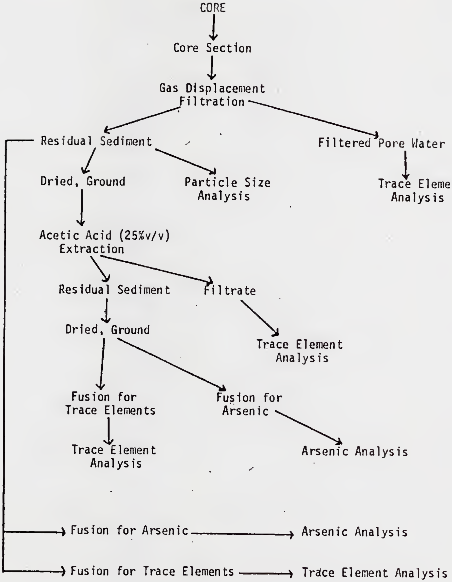


Figure 2.7

Flow chart for analysis of cores

nitrogen gas pressure forced liquid through the core sediment to the bottom of the core tube. Here it was passed through a 5.5 cm diameter glass filter emplaced to retain sediment within the tube. As the pore water left the unit it passed through a 0.45 micron millipore filter and into the suction flask to which 25 ul of nitric acid had already been added. This unit was designed to minimize contact of core pore water with the air prior to stabilization by acidification. Core pore water volumes were often small. Consequently trace metal analyses were prioritized as follows: arsenic, zinc, manganese, copper, and iron. One blank consisting of deionized, distilled water was run through the gas displacement-filtration unit for each core processed.

After extraction of core pore water the remaining sediment was pushed out of the tube into a clean plastic container. The core section was split in half lengthwise and one half placed in a clean beaker to be dried at 70oC. After removal of subsamples for carbon and grain size analyses, the other half was kept in the container and frozen. The dried portion was ground and used for the acetic acid extraction, aqua regia digestion, and lithium metaborate fusion-dissolution as described for the grab samples.

SOIL SAMPLES

Soil samples were prepared for analysis by trimming organic matter from the upper surface of the cores, then trimming the cores to equal length. Sometimes the soil cores were so dry that no shape was retained. For these, any grass or pieces of organic matter were removed. All soil samples were carefully seived through a nylon mesh screen into clean plastic containers. Clean plastic gloves were worn for seiving to reduce contamination. The screen was rinsed with acid-wash then deionized water, and then air-blown dry between samples. Once dried and seived, soil samples were extracted with acetic acid following the procedure described for grab samples. The acetic acid

extraction procedure is a much more harsh extractant than usually used for agricultural soils and so probably extracts more metals than would actually be readily available to plants. Since our intent was to quickly determine whether there might be any gross surficial contamination of soils in the area, this extraction procedure was considered most expedient.

PROJECT QUALITY CONTROL

GENERAL

In the laboratory all glassware and containers for samples were acid-washed prior to any contact with any portion of sample. Acid washing consisted of filling the vessel with 50% HCl (v/v) and allowing this vessel to sit, filled, for a minimum of 2 hours. The acid was poured off for reuse and the vessel rinsed 3 times with deionized, distilled water and allowed to air dry. All utensils, eg. spatulas, plastic implements, mortar and pestle, etc., were rinsed thoroughly with acid wash then rinsed thoroughly with deionized, distilled water and air-blown dry before use. Filters were left in individually sealed packets until use. All chemical reagents used were "Instra-Analyzed" grade acids or the purest forms readily available, eg. "Puratronic" lithium metaborate.

CHAIN-OF-CUSTODY AND SAMPLE STORAGE

Marin Popoff and Les Sartor were responsible for custody of all well water samples from time of collection to delivery to the appropriate laboratory for analysis. Carrie Johns was responsible for custody of all sediment samples and extractions from time of collection and preparation until delivery to the designated laboratory for analysis. Paul Vandenberg and Stan Carlson received samples for the Gordon Environmental Studies Laboratory and

were responsible for their custody until analysis was completed and the samples returned to the Geology Department. All samples were assigned a blind number by Johns, Sartor, or Popoff before delivery to the labs. Chain-of-custody log sheets detailing samples, blind numbers, parameters to be analylzed, and responsible personnel were kept for all samples transferred. These sheets are on file at the Geology Department.

Samples delivered to the analytical laboratories were splits of the original well water samples or sediment preparations. The original samples were kept in locked storage facilities in the Geology Department.

ACCURACY

(1) Reagent blanks were routinely prepared and analyzed with all sediment extractions at a level of 5 to 10% depending on the preparation. Metal concentrations in blanks were uniformly low and were taken into account, where necessary, in final calculation of metal concentrations in the sediments. Table F1 in Appendix F summarizes average blank values by metal for different extractions.

(2) Accuracy of water sample results was assessed by use of water quality control standards of trace metals in water prepared either by the National Bureau of Standards: SRM 1643a; U.S.E.P.A. Environmental Monitoring and Support Laboratory (Cincinatti) amid the regular samples to the analytical laboratories. For sediment extractions, two sediment standards available from NBS, SRM 1646 Estuarine Sediment and SRM 1645 River Sediment , were used to assess accuracy of the lithium metaborate fusion-dissolution and aqua regia extraction. Table F2 (Appendix F) summarizes average % bias found for various metals in water standards. The average % bias found for the Gordon Environmental Studies Laboratory is based on their own records of numerous

analyses of five different certified standards (SRM 1643a Trace Metals in Water and four E.P.A. EMSL standards). Most metal concentrations in these standards necessitated use of a graphite furnace rather than flame atomic absorption spectrophotometry. Analysis with the graphite furnace improves sensitivity but is often less precise than analysis by flame due to the small volumes used. Overall accuracy for analysis of certified standards by the GEVST Lab was good. Average % bias for the Rocky Mountain Analytical Lab (RMA) is based on 6 samples of 2 EMSL quality control samples submitted to them as unknowns. Based on these results, accuracy of metal analyses of water samples is excellent.

Accuracy of the lithium metaborate fusion-dissolution was evaluated by fusion of replicate samples of SRM 1646 and SRM 1645. Mean measured concentrations of iron, manganese, and zinc were compared to mean certified values and the mean % recovery calculated. These are presented in Table F3 of Appendix F. Mean % recovery of manganese was 95.9% for the Estuarine Sediment and 106% for the River Sediment. Both mean measured concentrations fell within the NBS suggested acceptable limits. Recovery of zinc averaged 82.6% for the Estuarine Sediment and 91.7% for the River Sediment. Zinc recovery for both standards was similar to that reported by Cantillo and co-workers (1984) for the same method. Total zinc values reported in our study may be approximately 10% low. Percent iron recovery was 89.9% for Estuarine Sediment, similar to that of Cantillo and others (1984). Recovery of iron from the River Sediment was somewhat lower: 82%. Cantillo and co-workers noted formation of a black insoluble magnetic phase during fusion of the River Sediment. We observed a similar insoluble phase in our River Sediment fusions. Cantillo and others believed this phase was chrome magnetic due to the high chrome and iron contents of the sediment and that this formation accounted for the lower iron recoveries from the River Sediment standard. Overall accuracy of this fusion

method was very good for these three elements.

Accuracy of the four hour aqua regia digestion was evaluated by the replicate digestion of Estuarine Sediment samples. Mean concentrations of arsenic, cadmium, copper, and lead, certified values for these metals, and average % bias are reported in Table F4 (Appendix F). Mean arsenic concentrations showed an average bias of +108%. According to C. Wibby, Chemist and Project Manager at RMA Lab, these sample were analyzed by ICP and the variation could be due to instrumental variation at the concentrations measured in the solutions (1984, personal communication). RMA Lab has been asked to re-analyze these samples via hydride or furnace, which are more sensitive, and re-report the results. The concentrations in these solutions were at the level of those in solutions for grab samples and core samples from the Blackfoot arm of the reservoir. All the reported concentrations for the other samples are above the level at which this much instrumental variation should occur (C. Wibby, 1984, personal communication). Consequently, final concentrations of samples from Blackfoot grab samples and core #1 samples (for this extraction only) were adjusted downward by 50%. Copper and lead % biases averaged -33.3 and -33.5%. Again, similar concentrations were only found in the Blackfoot samples. Total copper and lead concentrations reported have been adjusted upward 33.34% for Blackfoot samples only. Samples from the Clark Fork River arm of the reservoir were much higher and well above the range of the Estuarine Sediment. The bias at these higher levels is uncertain. Clark Fork River samples were not adjusted and should be considered conservative. Average % bias for cadmium was 369% for the Estuarine standard. Reagent blank values were very low: mean = 1.2 ng/ml (ppb). We have not found any published reports of cadmium analysis for this standard to use for comparison. Total cadmium values reported here should be viewed cautiously. However we have no reason to

question the acetic acid extract values for cadmium and these values were comparable to the total values. There may be more cadmium in the standard than reported.

Finally, accuracy for all types of samples was assessed by % recoveries from spiked samples. These results are summarized by element for each sample type and laboratory in Table F5 (Appendix F). Average % recovery of arsenic from spiked samples for all sample types was very high - 92% and higher. Recoveries of copper, cadmium, iron, manganese and zinc were also high. % recoveries for lead were lower at the low concentrations observed in well water and pore water samples. Recovery of nickel in both pore water and the acetic acid extracts was high but variable (107.7 and 128%).

PRECISION

Precision of results was evaluated by several methods: replicate digestions, replicate analyses done by the laboratories, and analysis of split samples.

Table F6 summarizes replicate analyses done by the various analytical labs. These are reported as either average % difference from the mean or average relative standard deviation by sample type and laboratory for each element. Overall, replicate analyses demonstrate high precision. Average percent differences from the mean were mostly well under 10%, with the exceptions of lead in well and pore water, manganese in well water (approximately 9.5%), and nickel analyses on pore water and acetic acid extracts.

In Table F7 of Appendix F, the precision of duplicate collections of water samples and duplicate sediment extractions is summarized. For the acetic acid extractions, the average percent difference from the mean value was very good, ranging between 3.9% for manganese to 8.5% for lead. Zinc was more

variable at 11.1% Nickel concentrations were much more variable at 16.8%. Precision of lithium metaborate fusions performed in duplicate was also good. Average % differences from the mean were 7.7% for iron, 7.4% for manganese, and 8.0% for zinc. Precision of aqua regia digestions was very high for copper, lead, and cadmium : 2.30%, 2.65%, and 3.52%. For arsenic the average % difference from the mean for duplicate digestions was much higher at 14.36%. Rocky Mountain Analytical Lab is reanalyzing those samples at the lower end of the sensitivity range for the ICP to see if instrumental variability can be minimized (C. Wibby, Project Manager, RMA, personal communication, 1984). Precision of organic carbon analyses on reservoir sediments using a LECO furnace was very high; average percent difference from the mean value was only 1.30%.

Precision of aqua regia extractions and the influence of length of digestion was investigated by performing a series of digestions using equal sediment sample sizes (.75 to .82 grams) and equal amounts of aqua regia: 25 ml of 3HCl:1HNO3 (v/v). Digestions were run for 1,2,3,4, and 5 hours and performed in triplicate. Results are summarized in Table F8 in Appendix F. Relative standard deviations for arsenic, cadmium, copper, and lead at the four hour digestion (the time used in this study) were low: 6.45%, 4.68%, 3.61%, and 2.19%, respectively. Highest mean metal concentrations, especially for copper and lead, occurred with 1 or 2 hour digestions. Relative standard deviations for these digestion times were mostly less thhan 5%, suggesting that shorter digestion times would be acceptable and even preferrable for these four elements.

Samples of well water and lithium metaborate fusions were split and sent under separate blind numbers to the laboratories for analysis. Analytical precision for the fusions, as estimated by the magnitude of the relative

standard deviation of triplicate splits, was excellent. For iron (Table F9, Appendix F) relative standard deviations were 2.67 and 1.81%, for manganese 3.89 and 3.96%, and for zinc 1.03 and 1.75%. Well water samples were also split and sent separately for analysis. The relative standard deviation for arsenic was 5.19% (n = 27), for manganese 1.29% (n = 19), for lead 0.0% (n = 6), for copper 10.82% (n = 6), for zinc 1.81% (n = 19) and for iron 23.1% (n = 20).

STATISTICAL METHODS

Project results were evaluated using the SPSSX statistical package available on the University of Montana DEC-20 mainframe computer. Graphs of hydrogeologic and sediment data were generated by the SPSSX Graphics option. A discussion of the statistical methods used for analysis follows.

HYDROGEOLOGIC ANALYSES

In an effort to identify the relationship between the concentrations of various constituents, Pearson correlations were derived for comparison of chemical constituents with chemical constituents, water table elevation and the discharge of the Clark Fork River. These analyses were performed for the complete data set, for August-September, 1983, and for November-December, 1983.

SEDIMENT ANALYSES

Data for pore water extractions, acetic acid extractions, and total metal concentrations for grab samples were divided into two groups according to whether the sample sites were located in the Blackfoot or ClarkFork arm of the reservoir. Descriptive statistics eg. mean, standard deviation, and range, were compiled by use of the SPSSX Condescriptive program. Variances of metal concentrations were not homogeneous for the Blackfoot and ClarkFork arms of

the reservoir. The log10 transformation did not improve homogeneity of the variances except in a few cases. Consequently, the Wilcoxon Rank Sum Test, available as part of the nonparametric test package in SPSSX, was used to test whether metal concentrations in the two arms of the reservoir could have come from the same distribution or population (Sokal and Rohlf, 1981). This test is a nonparamteric test equivalent to a t-test in purpose. Correlation coefficients were computed among metals and particle sizes and % organic carbon for pore water, acetic acid extracts, and total extracts by use of the Pearson Correlation and Nonparametric Correlation packages of SPSSX. In all tests involving significance levels, ie. the Wilcoxon Rank Sum Test and correlation coefficients, $P<0.05$ was the level used to establish significance of results.

RESULTS OF HYDROGEOLOGIC INVESTIGATION

The presentation of the hydrogeologic results describes the hydrogeologic systems operating in the Milltown area. The source of contamination of the Milltown water supplies, the mechanisms required to transport As and other constituents, the selection of a site for a new community supply, and the effects of shutting down the four existing wells and starting up a new one can only be addressed by understanding the natural ground-water system. This section will describe the natural ground-water systems operating in the area and then address the issues described above.

The results are organized into four sections. The first describes the occurrence of ground water in the Milltown area. The second section describes the movement of ground water and the the factors effecting water table fluctuations. Analyses of aquifer tests and the distribution of the resulting hydrogeologic properties of transmissivity and hydraulic conductivity are presented in the third section. Finally the occurrence and distribution of chemical constituents in the ground-water systems are described. The results of the soil survey are also presented in the last section.

OCCURRENCE OF GROUND WATER

The principal ground-water system in the Milltown area is composed of the unconsolidated sand, gravel, and boulders which overlie Precambrian bedrock. The water found in the alluvial aquifer is unconfined. The metasediments which compose the bedrock are generally poor aquifers. Of the 13 holes which penetrated bedrock small amounts of measureable ground-water flow were

recorded only at 111 and 104. In both cases, the rock appeared to be highly weathered and was softer than the bedrock encountered at other sites. The driller estimated about 100 gpm at site 111 and about 50 gpm at site 104 were being blown from the twenty feet of open hole drilled into bedrock. Based on the general absence of water in the bedrock the unconfined aquifer will be the focus of this discussion.

Figures 3.1 and 3.2 present geologic cross sections constructed from project drilling and well driller's logs which show the depth to bedrock, general geology and the position of the water table. Seismic refraction methods and actual drilling were used to predict depth to bedrock and the thickness of the overlying alluvium is shown in Figures 3.3 and 3.4, respectively. Statistically, the seismic data correlated fairly well with the actual thickness of alluvium(coef.=0.60, n=13). For this discussion the drilling data-based isopach map shown in Figure 3.3 is primarily used to describe the configuration of the unconsolidated deposit. However, the seismic data were in some cases derived at locations where no drilling information is available and hence are used to extrapolate the drilling data.

The alluvium is only 60 ft thick at the reservoir edge southwest of Milltown, but generally thickens to the north and northeast. It is 160 ft thick at well site 109. The data derived from drilling shown in Figure 3.4 indicate the presence of a bedrock high just east of Milltown where the alluvium is 100 ft thick at well site 104. A similar feature was interpreted from the seismic data shown as a 60 ft isopach east of Milltown. Shown as closed isopach lines in Figure 3.3 the seismic data also indicate a small area of aquifer thickening in the northern part of the area; the drilling data corroborates this. The isopach lines shown in Figure 3.4 bow south in the same vicinity. However, the seismic data predicted the presence of a second bedrock high-thin alluvium zone parallel to the railroad right of way in the

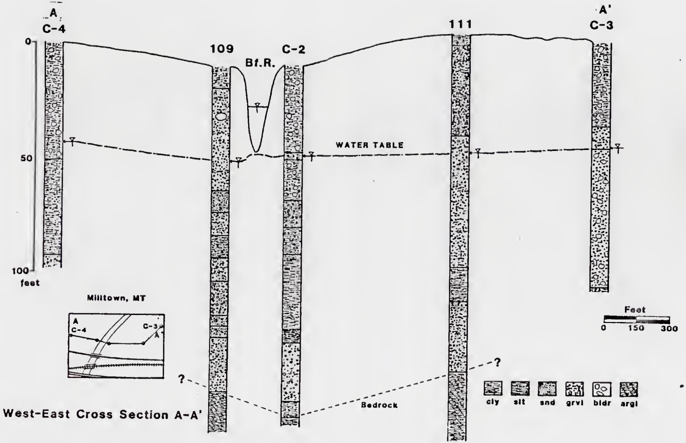


Figure 3.1: East-West cross section A to A'.

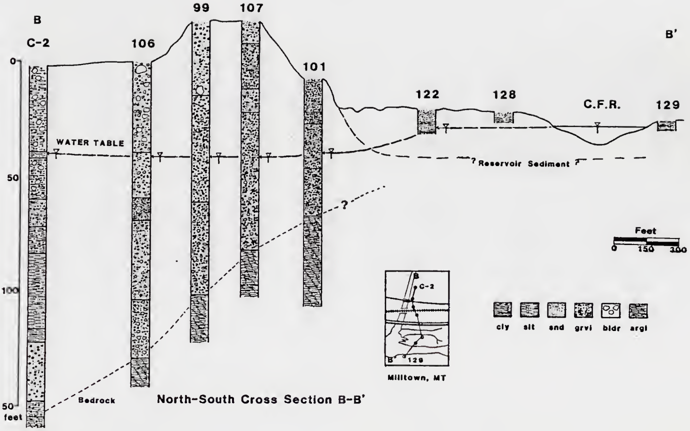


Figure 3.2: North-South cross section B to B'.

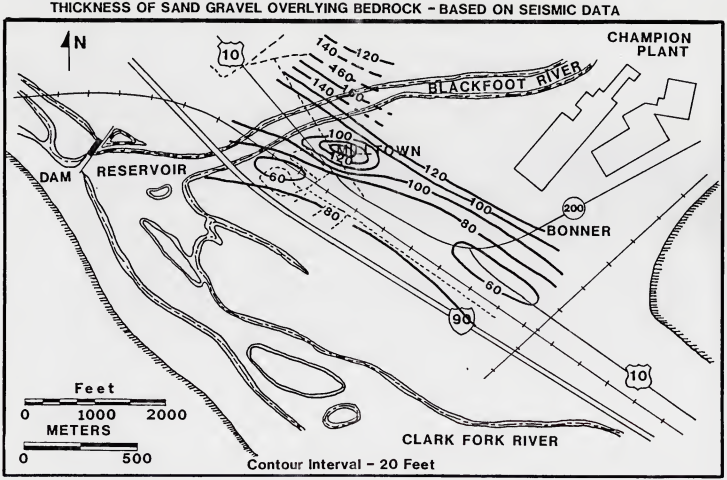
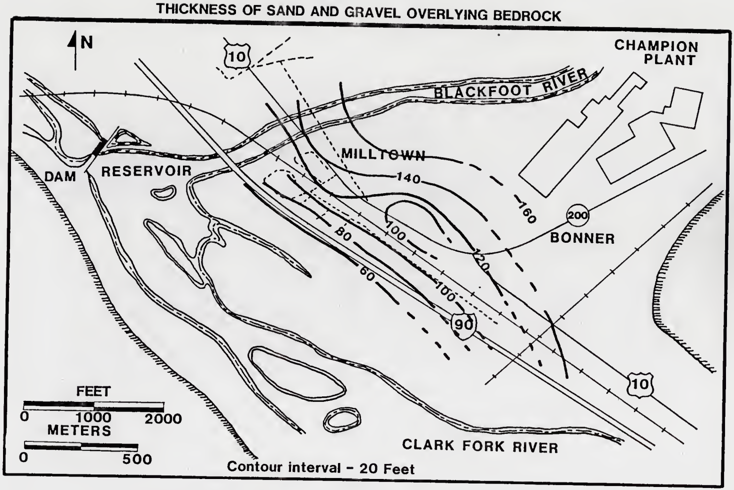


Figure 3.3: Sand and gravel isopach map based on seismic data.



THICKNESS OF SAND AND GRAVEL OVERLYING BEDROCK

Figure 3.4: Sand and gravel isopach map based on known depth to bedrock data.

southern portion of the study area between the contaminated community wells and an area of good water quality. Well 99 was drilled within the seismic anomaly and bedrock was encountered at 120 ft. Figure 3.3 shows that a thinner zone of sand and gravel was not present. Interpretation of seismic data also indicated the alluvium begins to thin to 120 ft just north of well site 109 on the west bank of the Blackfoot River.

An isopach map of the saturated thickness of the alluvium-aquifer thickness was prepared from water level data for the fall of 1983 (Figure 3.5). The aquifer generally thickens from 15 ft at I 90 to 120 ft near well C2 just north of Milltown. The aquifer gradually thickens parallel to the Clark Fork portion of the reservoir, from 9 ft at well site 100 to 25 ft at well site 101 and 102 to 90 ft at well site 110. The aquifer thins to 8 ft at well site 104, corresponding to the bedrock high identified just east of Milltown. If a similar bedrock high is present parallel to the railroad tracks in the western portion of the study area, less than one foot of saturated aquifer would be present.

In summary, the unconfined sand and gravel aquifer is thinnest in the southwest and south, where bedrock comes to within 60 ft of the land surface, and just east of Milltown, where bedrock is within 84 ft of land surface. It generally thickens from the edge of the reservoir parallel to I 90 to the north and northwest at which the thickness reaches 155 ft at well C2.

MOVEMENT OF GROUND WATER

Potentiometric maps for the unconfined aquifer which show the distribution of hydraulic head and the interpreted direction of ground-water flow for April 1982, September 1983, November-December 1983, March 1984, and June 1984 are presented in Figures 3.6, 3.7, 3.8, 3.9, and 3.10, respectively.

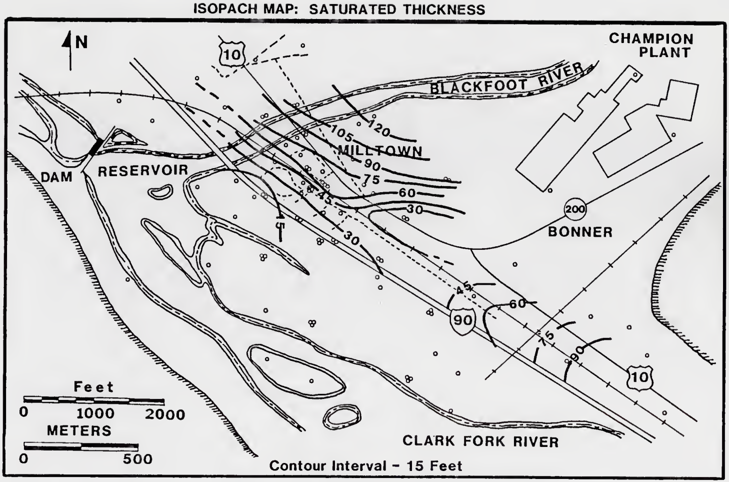
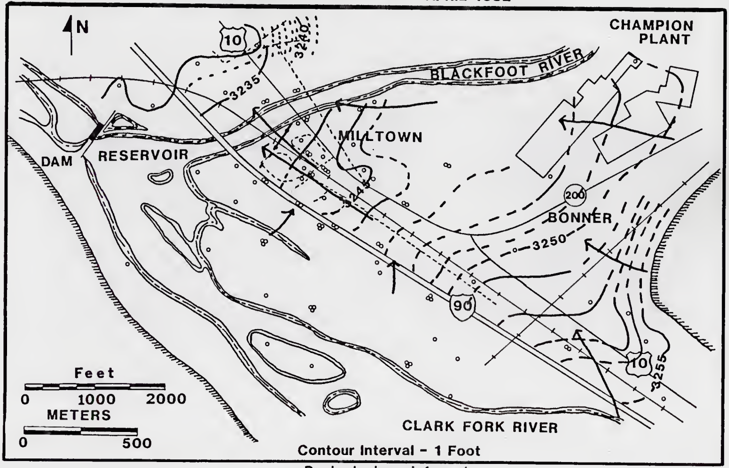


Figure 3.5: Saturated thickness isopach map.

The water table maps prepared in April 1982 and November-December 1983, utilized the most extensive data sets, with over 50 points. Other maps were constructed using about 30 measurements and are considered gross generalizations of seasonal distribution of head. They are presented for examination of seasonal trends.

Potentiometric surfaces constructed in November-December 1983 and June 1984 show components of flow from the reservoir sediments both to the reservoir in response to lowering of the reservoir stage proir to water level data collection and to the alluvial aquifer. In each figure for the five periods examined, three principal components of flow are apparent. The first travels from the reservoir sediments south of Milltown to the northeast. November-December, March and June data show steep gradients averaging 0.02 ft between the reservoir and the wells located between the lanes of the interstate highway I 90. Woessner and Popoff (1982) noted that, though head data for the reservoir sediment ground-water system was unavailable, the head difference between the surface of the reservoir and the Milltown wells was as large as 17 ft adjacent to the reservoir, and thus a reservoir component of flow probably existed. In general, a component of flow from the reservoir sediment exists and moves north, meeting a second component of flow derived principally from Clark Fork River recharge to the system in the southeastern-most part of the study area. This water generally parallels the resevoir to the northwest and flows through the southern portion of Milltown, as shown in Figures 3.6 through 3.8. Interpretation of March and June data show that the Clark Fork and reservoir flow component may swing northward. However, the more detailed April and November-December data indicate the combined flow system parallels the reservoir and moves to the northwest. The thin aquifer thickness, about 8 ft, at well site 104, may also inhibit flow to the north and channel it more to the northwest, as indicated by the March and June data.

POTENTIOMETRIC SURFACE MAP - APRIL 1982

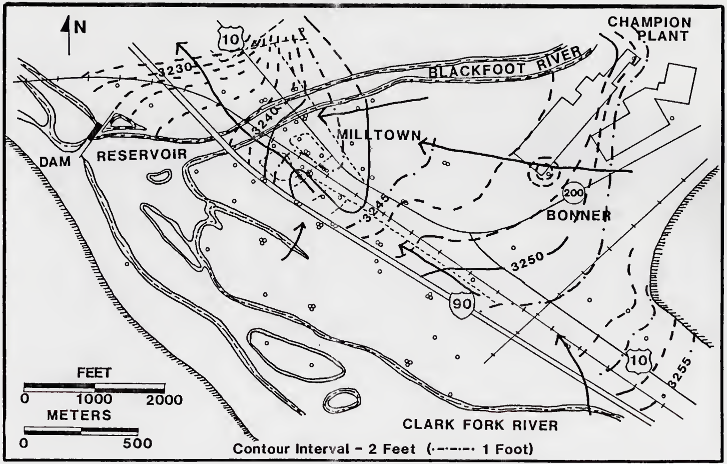


Contour Interval - 1 Foot

Dashed where inferred

Figure 3.6: Potentiometric surface map for April, 1982. Arrows represents direction of ground-water flow.

POTENTIOMETRIC SURFACE MAP - SEPTEMBER 1983



Contour Interval - 2 Feet (·-·-·-· 1 Foot)

Dashed where inferred

Figure 3.7: Potentiometric surface map for September, 1983. Arrows represent direction of ground-water flow.

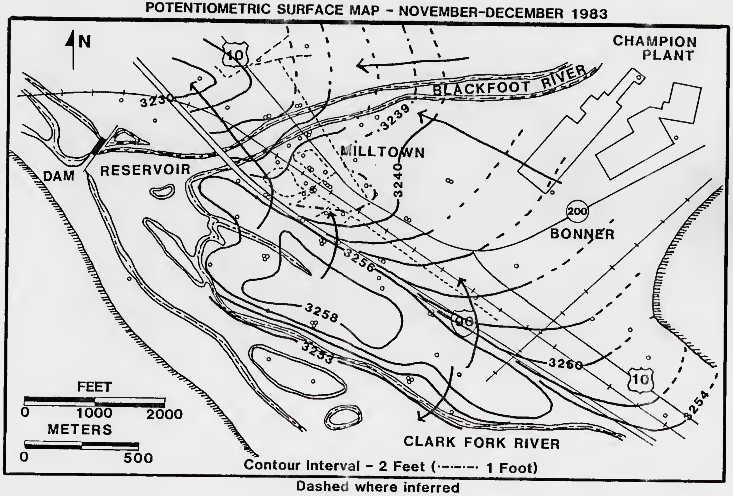


Figure 3.8 Potentiometric surface map for November-December, 1983. Arrows represent direction of ground-water flow.

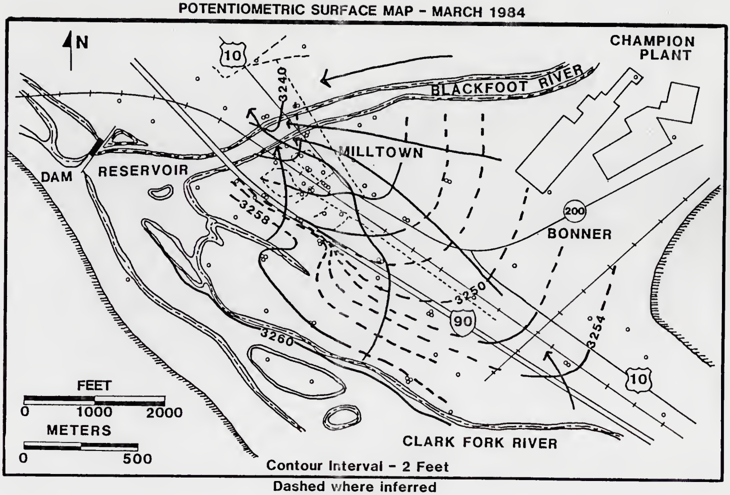


Figure 3.9: Potentiometric surface map for March, 1984. Arrows represent direction of ground-water flow.

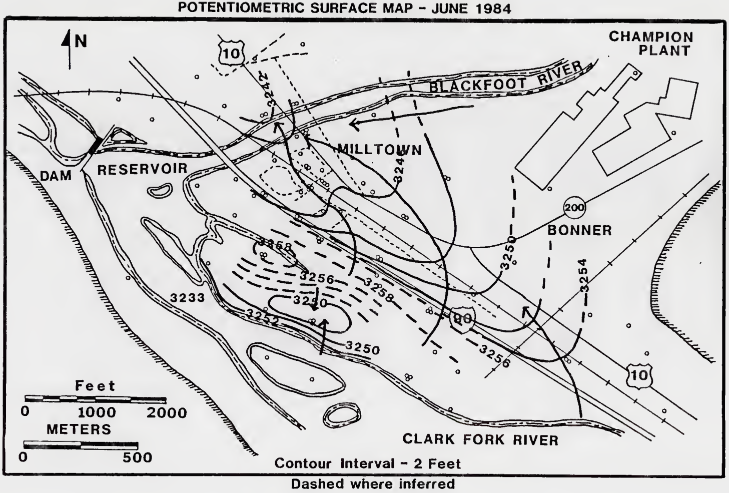
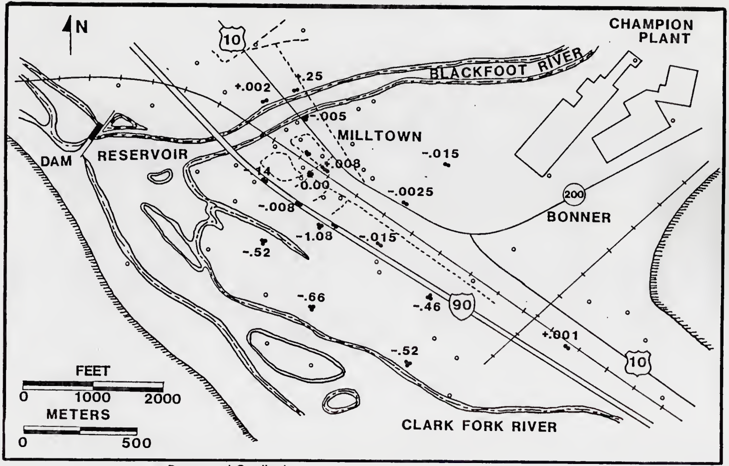


Figure 3.10: Potentiometric surface map for June, 1984. Arrows represent direction of ground-water flow.

VERTICAL GRADIENTS



– = Downward Gradient

+ = Upward Gradient

Figure 3.11: Vertical gradients for nested wells and sandpoints.

A third component of flow seen in each figure parallels the Blackfoot arm of the reservoir and flows through the Champion mill area to the southwest. It converges with the component of flow moving parallel to the Clark Fork arm of the reservoir and both components swing northwest, flowing underneath the Blackfoot arm and then west to discharge into the Clark Fork River below the Milltown dam.

The water table maps described above assume that flow in the aquifer is horizontal. The potential for vertical components of flow was examined by calculating vertical gradients from the monitoring well nests. The distribution of vertical gradient is presented in Figure 3.11. Negative gradients indicate ground-water flow is downward from the water table. Positive gradients indicate and upward movement of water from depth to the water table. Generally, water from the reservoir sediment moves under steep vertical gradients downward and to the north. In the area just north of the reservoir sediments, the vertical gradients range from 0.001 to 0.008, indicating the flow is generally horizontal. Vertical gradients at site 111 and 103, about -0.015, indicate downward flow is the principal component at those sites. Gradients at sites 100, 107 and 104 indicate that flow either is non-existent between bedrock ground water and the alluvial aquifer and thus is horizontal at 107 or moves from the water table to the bedrock at the other two sites. The only major upward gradient seen in the area is at site 109 on the west bank of the Blackfoot arm of the reservoir. This may indicate the presence of a partial confined zone at the aquifer base.

The water table fluctuations at the study site are in part represented by the spacial change of position of equipotential lines shown in seasonal potentiometric surfaces. Hydrographs prepared from continuous records collected for wells G and 8 are presented in Figures 3.12 and 3.13. Water

levels were also obtained for additional wells during routine monthy and quarterly water quality sampling. All water level data collected for wells since February 1982 are tabulated in Appendix E. The hydrographs for wells without recorders mirrored those of wells G and 8.

Based on two and one-half years of record, data show the water table reached its highest position in June, but then peaked again in December. Water levels were declining during initial data collection in February, 1982, and then rose from a low in April to peak twice in June. A sharp drop in the water table occurred in July; then it rose slightly and remained mostly level until December, 1982, at which time it rose again then declined into January. A similar pattern is seen in 1983, with the water table declining into April, then rising to a peak in June. The water table showed a fairly rapid drop then a slight rise in July and slowly declined until December when it plummetted to lowest level of the year. It again rose in late December and peaked in January, 1984. The water table declined rapidly in February and then generally rose until the project ended in June, 1984.

Precipitation, stream discharge and reservoir stage records were evaluated and Pearson correlations calculated to determine the dependency of water table fluctuations on Clark Fork and Blackfoot river discharges and the reservoir stage changes for February, 1982, to January, 1984, period. Water table change in the Milltown wells does not appear to be dominated by direct precipitation. Water levels did appear to rise in correspondence to storm events in February, late June and mid-December of 1982 and mid-July 1983; however, the separation of recharge from the increase in river stage and discharge resulting from the storms is not clear. Figure 3.14 presents the hydrographs for the Clark Fork River below Milltown dam. The hydrographs of discharge for the Clark Fork and Blackfoot rivers are virtually identical. When the hydrograph of the Clark Fork River is visually compared with the

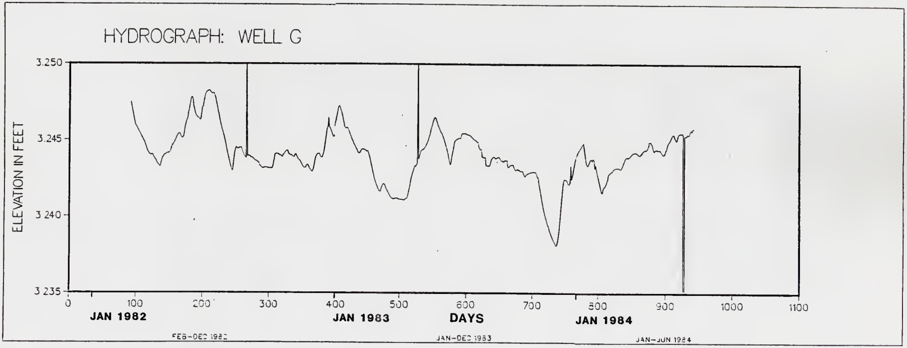


Figure 3.12: Hydrograph from well G - February, 1982 through June, 1984.

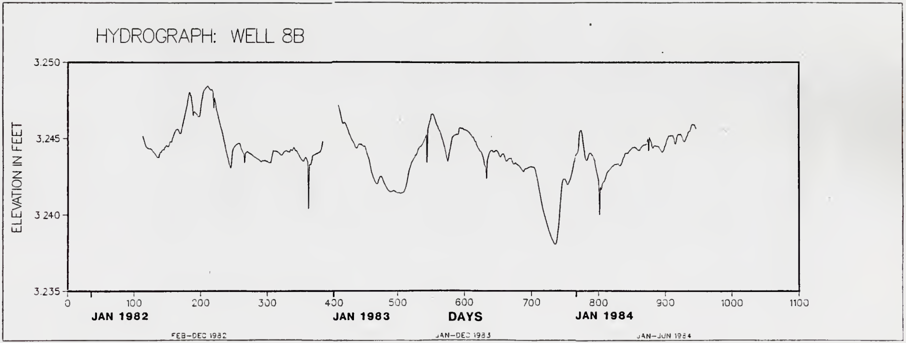


Figure 3.13: Hydrograph from well 8B - February, 1982 through June, 1984.

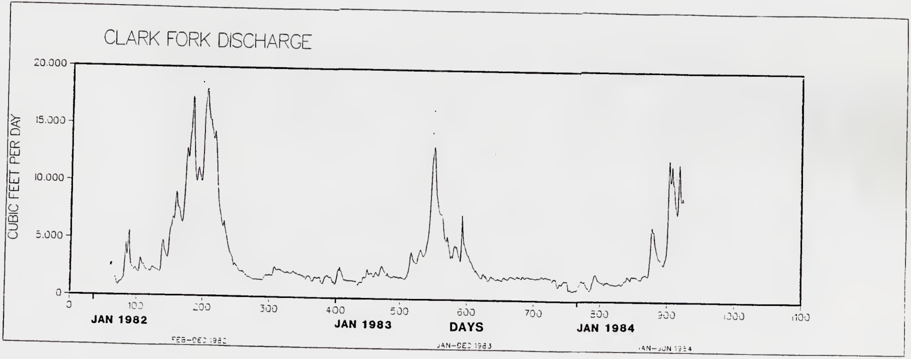
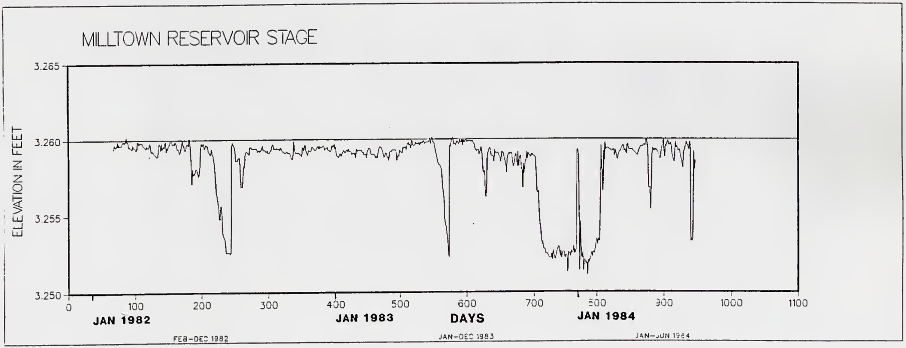


Figure 3.14: Hydrograph of Clark Fork River discharge - February, 1982 through May, 1984.



Figur 3.15: Hydrograph of Milltown reservoir stage - February, 1982 through June, 1984.

water table hydrographs it appears the water table generally fluctuates in response to changes in stream flow. Comparison of the water table hydrograph and the reservoir stage hydrograph shown in Figure 3.15 shows limited response of the water table to sharp declines in pool elevation. Statistically, the correlation coefficient for the water table data for well G and Clark Fork discharge is 0.60 (n=639). The correlation of the water level fluctuations in G with the reservoir stage is 0.18 (n=802). From these correlations the river appears to exert more control over the aquifer than does the reservoir. However, since the reservoir stage is maintained at a fairly constant operating head, it is providing more of a continual input of water to the Milltown system and thus does not appear to affect the hydrographs. However, when the stage is dropped (though stream flow remains fairly constant), the water table generally declines in response to the reduction of recharge from the reservoir.

In summary, three components of ground-water flow make up the flow system in the unconfined sand and gravel aquifer underlying the Milltown area. Ground-water recharges the aquifer from the Clark Fork River, the Blackfoot River and the Milltown Reservoir. Components of flow associated with these sources of recharge include flow in the southern portion of the study area from the reservoir to the north, flow from the southeastern portion of the area to the northwest, and flow paralleling the Blackfoot River from the northeast to the southwest. All components meet in the vicinity of the contaminated community wells and then move west and southwest, discharging into the Clark Fork River below the Milltown dam. Analysis of vertical gradients in the area show that steep downward gradients are present in the reservoir sediments and flow in the alluvial aquifer is mostly horizontal. The bedrock generally yields only small amounts of water to wells where the

rock is highly weathered and fractured and so is not an aquifer. Vertical gradients evaluated for wells in the bedrock show water moves either horizontally or from the alluvial aquifer to the bedrock.

QUANTIFICATION OF GROUND WATER

The results of aquifer hydraulic conductivity and transmissivity calculations are presented in Table 3.1 and Appendix C. Figures 3.16 and 3.17 show the spacial distribution of parameters. Comparing the two figures shows that the areas of highest hydraulic conductivity also correspond with the thicker portions of the aquifer and also have the highest transmissivities. Generally, the hydraulic properties increase to the north and southeast. The only exception occurs at well site 105 located just across the railroad tracks and north of the contaminated community wells. The hydraulic conductivity at the site is 290 ft/d, which is an order of magnitude lower than at any other site.

Table 3.2 lists ground-water velocities calculated from gradients derived from November-December potentiometric data (Figure 3.8), the hydraulic conductivity data, and the assumed porosity of 0.25 for the region associated with each test site. The average ground-water velocity rate ranges from about 1.9 ft/d at site 105 to 1,900 ft/d at site 106.

The flux of ground water through a cross-section of the aquifer can be approximated for a water table aquifer using Darcy's law which states the discharge through a known area is determined by multiplying the hydraulic conductivity by the horizontal gradient times the cross-sectional area (Fetter, 1980). The cross-sectional area representing the saturated alluvium parallel to the Clark Fork section of the reservior between the I 90 bridge and the I-90 railroad crossing, was to be 17,280 ft^2. A daily discharge of 1,300,000 ft^3/d from the reservoir to the Milltown area was calculated from

Table 3.1: Aquifer Test Results

Well	Q (gpm)	s' (ft)	K (ft/d)	$\bar{K}$ (ft/d)	T (ft^2/d)	$\bar{T}$ (ft^2/d)
102	115	.21	3710	3710	96,400	96,500
	187	.34	3715		96,600	
103	27	.08	2100	1950	65,200	60,550
	42	.16	1770		55,000	
	102	.42	1980			
105	29	.28	290	290	18,230	18,230
	52	.50	290		18,230	
106	125	.01	56,700	59,900	4,140,100	4,370,000
	210	.02	59,400		4,340,000	
	254	.02	63,600		4,640,000	
107	108	.04	13,600	14,000	573,000	590,000
	140	.05	14,200		595,100	
	165	.07	14,100		592,200	
108	29	.01	6500	6700	595,200	539,000
	50	.03	6800		552,000	
	107	.09	6700		539,800	
109	51	.001	15,100	15,700	1,600,000	1,672,000
	90	.001	16,900		1,800,000	
	254	.002	15,100		1,600,000	
110	20	.02	2560	2400	240,400	230,000
	60	.05	2580		242,100	
	143	.18	2200		208,500	

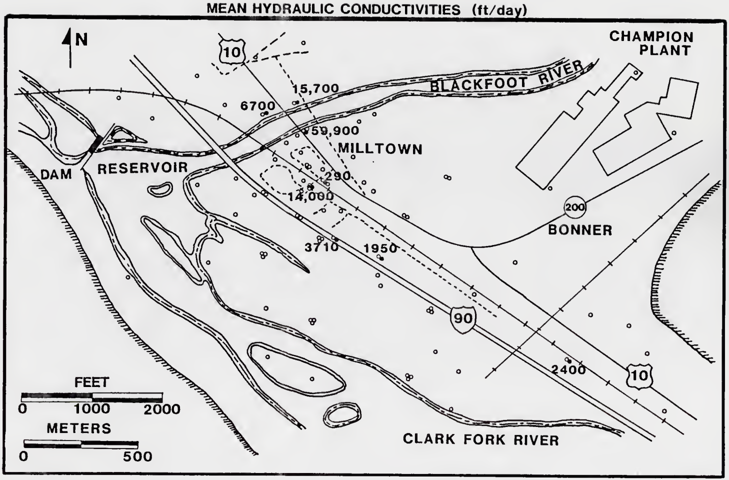


Figure 3.16: Mean hydraulic conductivities calculated from aquifer tests.

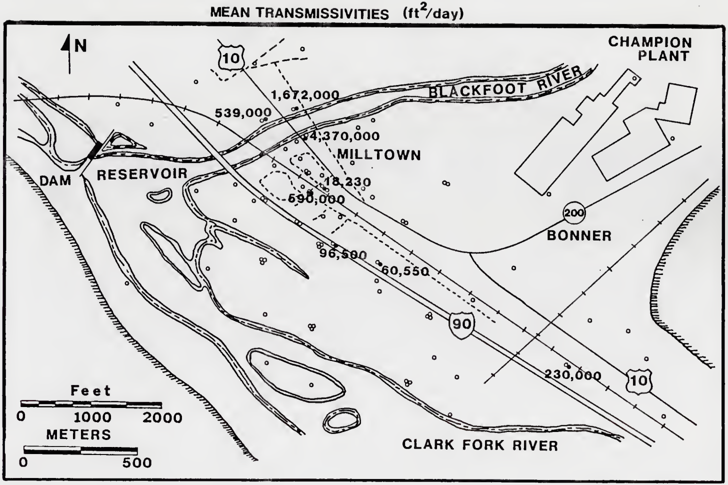


Figure 3.17: Mean transmissivities calculated from aquifer tests.

Table 3.2: Groundwater Velocity

Well	K (ft/d)	i	n	$\bar{v}$ (ft/d)
102	3710	0.02	0.25	297
103	1950	0.02	0.25	156
105	190	0.002	0.25	1.9
106	59,900	0.008	0.25	1917
107	14,000	0.008	0.25	447
108	6700	0.001	0.25	26.6
109	15,700	0.001	0.25	62.8
110	2400	0.008	0.25	78

the November-December data for site 102, using a hydraulic conductivity of 3,710 ft/d and a gradient of 0.02. A similar analysis for a 19,680 ft^2 cross sectional area near well site 107 yielded a ground-water discharge of 2,200,000 ft^3/d which would represent the flow of water through the area that includes the contaminated wells. If the total figure for the cross-sectional discharge near site 107 comes entirely from the flows moving northward from the reservoir and northwestward from the Clark Fork (and parallel to the reservoir), then 900,000 ft^3/d is contributed by the Clark Fork recharge component. Discharge through the aquifer at well site 105 would be a fraction of that found at the other sites. The presence of an area of low hydraulic conductivity at site 105 and the thin zone of saturation at site 104 to the east may help contain the ground-water system flowing south of the site; thus it may partially limit the movement of water to the north. However, the geologic log for the wells notes clay present in the sand and gravel at the completed depth of the test well. However, below well depth the clay is underlain by 50 ft of clean gravel and sand. Were the well completed in the lower portion of the aquifer, the hydraulic conductivity would possibly have been closer to the other values.

The operational impact of water wells in the Milltown aquifer was evaluated using a worst case scenario. Using the transmissivity values presented in Figure 3.17, the effect of pumping a well at 50 gpm at site 107 and 200 gpm at site 106 continuously for 40 years, assuming an 8 in diameter well, an aquifer storage coefficient of 0.2, the well is 100% effiecient and fully penetrating and that the aquifer receives no recharge during pumping was determined by using the Thies equation (Walton, 1970). The results of the analyses show that 0.36 ft of drawdown would occur in the pumping well located at site 107 in 40 years. The pumping of a well at 200 gpm at site 106 would

result in 0.02 ft of drawdown in the pumping well in 40 years. These very small values reflect principally the high transmissivity values for the aquifer in those areas. These values are not unrealistic and are further supported by observed drawdowns during aquifer testing and the lack of recorded drawdown effects during the operation of a new community supply well located 20 ft from continuously recording well 8.

In summary, the hydraulic conductivity and transmissivity values generally increase northward as the aquifer thickens. Of the 2,300,000 ft^3/d of water moving through the area of the affected wells, about 1,300,000 ft^3/d of that water appears to come from the reserovoir south of Milltown. The highest ground-water velocity was recorded at well site 106, 1,1917 ft/d. The aquifer is sufficiently prolific that, even under a worst case scenario after 40 years of continious discharge drawdown in fully penetrating 100% efficient pumping wells would be measured in tenths of a foot.

QUALITY OF GROUND WATER

The ground water quality section will focus on the unconfined alluvial aquifer. It will also describe the quality characteristics of the reservoir sediment and bedrock gound water, the general water type, and the spacial distibution of constituents. Secondly, the correlations of chemical constituents with each other, with water table fluctuations, and with Clark Fork discharge will be presented. Finally the interaction of the reservoir and the contaminated aquifer area will be examined. Tables of the water quality sampling results for the period from February 1982 through June 1984 are found in Appendix D. These tables should be referred to for the complete data on sampling frequency and results.

The general water chemistry of the ground water of the Milltown area is shown in Figure 3.18. The water in the unconsolidated aquifer is a calcium-

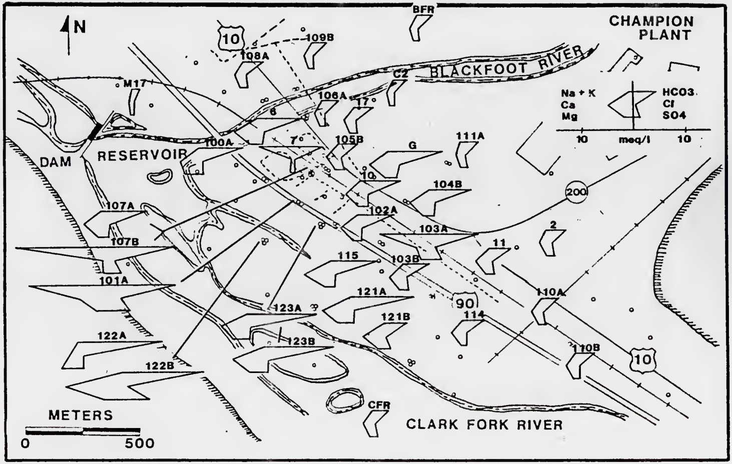
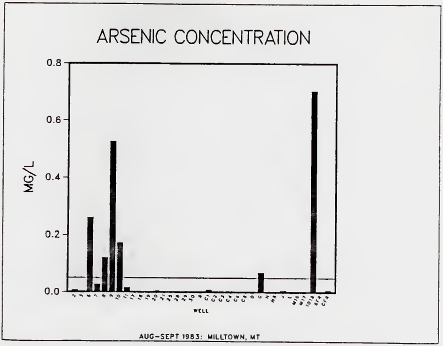


Figure 3.18: Stiff diagrams of major ions in selected wells.

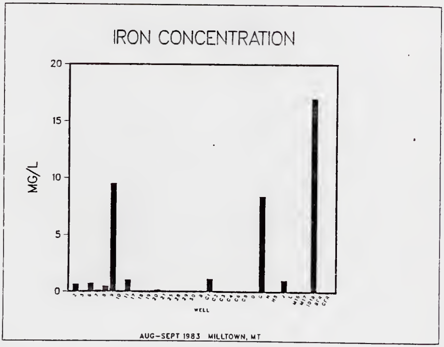
bicarbonate type. As seen by the relative size of the diagrams presented in the figure, the total dissolved solids (TDS) of the water is generally lowest (smaller diagram) in both the northern portion of the region near the Blackfoot arm of the reservoir and in the southeastern part of the area near the Clark Fork River. TDS is greatest at well sites 107B, 101A and 103A. Well 107B is finished in bedrock and the ground water is a high-TDS-sodium-bicarbonate type. Wells 101A and 103A are finished just above bedrock, but apparently also reflect bedrock chemistry as they are also a sodium-bicarbonate type. A third characteristic of wells finished in bedrock (at least at the three sites which have sodium bicarbonate dominated water) is the presence of fluoride in concentrations over 3 mg/l; concentrations for wells 107B, 101A and 103A are 8.6 mg/l, 4.5 mg/l and 3.6 mg/l, respectively (Appendix D). Well 7 has a similar type of water (Figure 3.18) and that may reflect bedrock water quality; however, the depth remains unknown and the water softener in use on well 7 replaces calcium with sodium. The fluoride concentration at well 7 is 0.40 mg/l, which appears to represent backgound for the alluvial aquifer.

Bar graphs showing the concentration of As, Mn, Fe, Ca, HCO_3, and TDS for 35 wells sampled before project drilling in August-September, 1983, are presented in Figures 3.19 through 3.24. Prior to monitoring well construction, wells 6, 8, 9, 10, G, and 101B contained arsenic levels that exceeded EPA drinking water standards. These wells also contained high levels of iron and manganese, and almost all other concentrations of chemical constituents exceed background levels. Appendix D presents in bar graph form results of sampling after completion of project wells in November-December for the same constituents listed for August-September. Figures 3.25 through 3.27 present November-December 1983 arsenic datas for monitoring wells, sandpoints in the



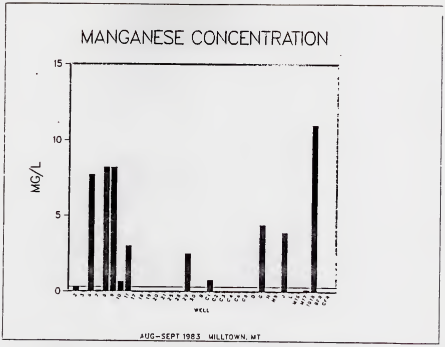
AUG–SEPT 1983: MILLTOWN, MT

Figure 3.19: Bar graph of arsenic concentrations in selected wells - August-September, 1983.



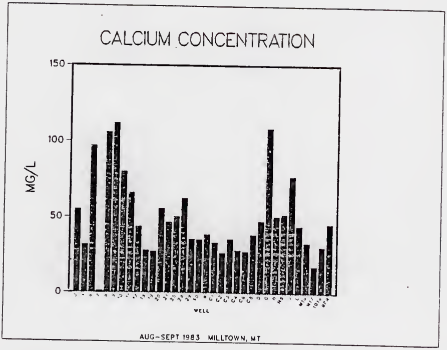
AUG–SEPT 1983 MILLTOWN, MT

Figure 3.20: Bar graph of iron concentrations in selected wells - August-September, 1983.



AUG-SEPT 1983 MILLTOWN, MT

Figure 3.21: Bar graph of manganese concentrations in selected wells - August-September, 1983.



AUG-SEPT 1983 MILLTOWN, MT

Figure 3.22: Bar graph of calcium concentrations in selected wells - August-September, 1983.

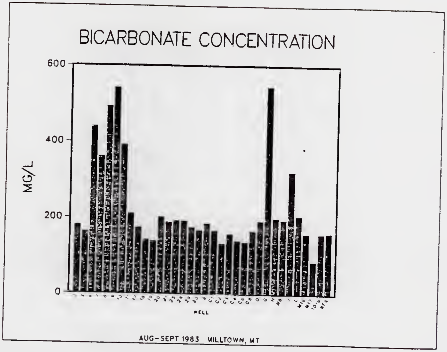


Figure 3.23: Bar graph of bicarbonate concentrations in selected wells - August-September, 1983.

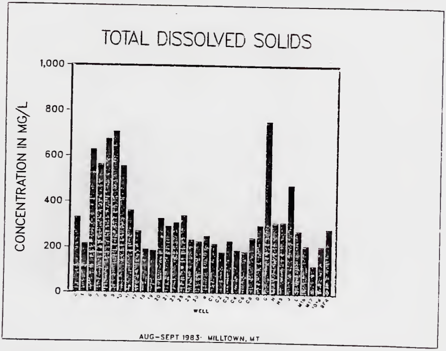


Figure 3.24: Bar graph of TDS in selected wells - August-September, 1983.

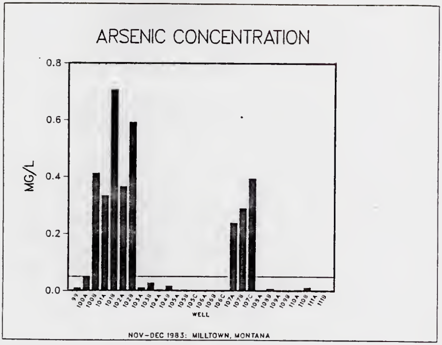


Figure 3.25: Bar graph of arsenic concentrations in project wells - November-December, 1983.

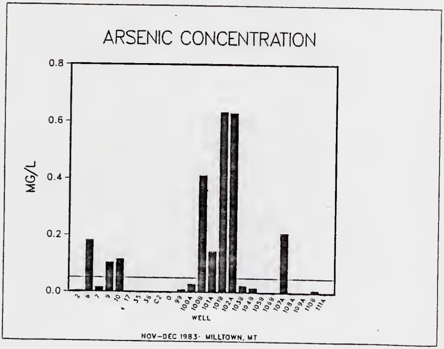


Figure 3.26: Bar graph of arsenic concentrations in selected wells - November-December, 1983.

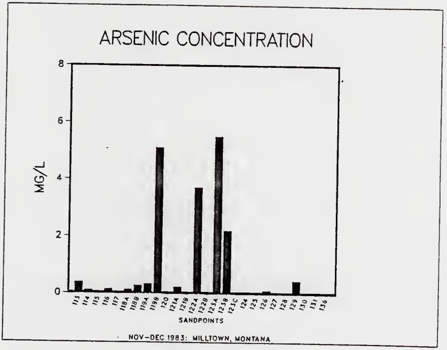


Figure 3.27: Bar graph of arsenic concentrations in sandpoints -- November-December, 1983.

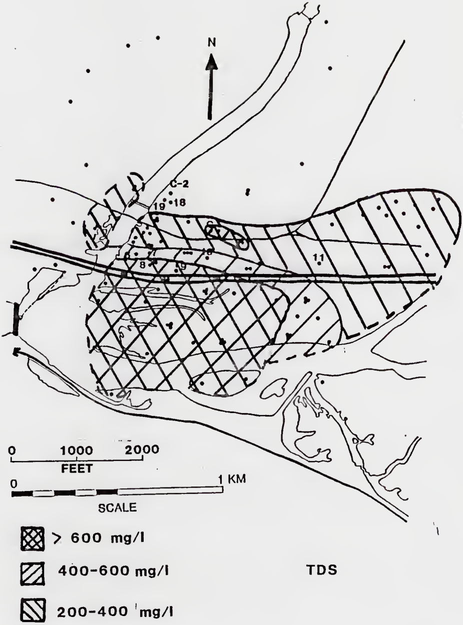


Figure 3.28: Distribution of TDS in the shallow ground water.

reservoir sediments, and selected existing wells in the study area. Evaluation of the data shows ground water at sites 100, 102, 107, 113, 114, 116, 118, 119, 121, 122, 123, 126, and 129 also exceeds the arsenic standards for drinking water. The wells located in the alluvial aquifer had arsenic concentrations less than 0.8 mg/l, with the highest concentrations found in wells completed inbetween the interstate lanes parallel to the reservoir. Sandpoint wells 119B, 122A, 123A, and 123B all contained arsenic concentrations which exceed 2 mg/l. Also manganese and iron concentrations were usually higher than at those sites with lower concentrations of arsenic. Bar graphs of arsenic, iron and manganese for March 1984, data are also presented in Appendix D.

The general distribution of arsenic, manganese, iron, and TDS in the alluvial and reservoir ground water is presented in Figures 3.28 through 3.31. Grouping of ground water by TDS shows three distictly different areas of TDS concentration (Figure 3.28). The ground water in the unsymbolled northern portion of the area contains less than 200 mg/l TDS. This represents the recharge of high quality water from the Blackfoot River. The second ground water component is represented by the zone in which the TDS is 200 to 400 mg/l, and it extends in the flow direction parallel to the reservoir. This component results from the recharge of Clark Fork River water in the southeast and possibly from mountain bedrock recharge. The third zone of ground water contains TDS of greater than 600 mg/l, and this water appears to originate in the reservoir sediments and to flow northward. An intermediate zone of 400 to 600 mg/l TDS water is interperted to represent a transition zone between components of ground-water flow of varying quality. The distribution of arsenic, iron and manganese show similar concentration patterns with the highest concentrations occuring in the southern Milltown area and in the reservoir sediment ground water. These patterns also correlate well with the

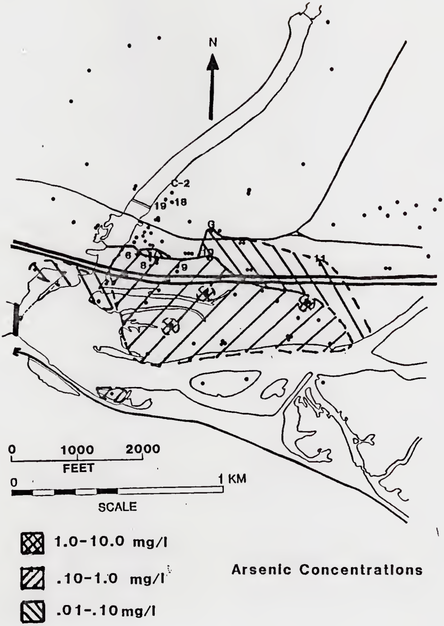


Figure 3.29: Distribution of As in the shallow ground water.

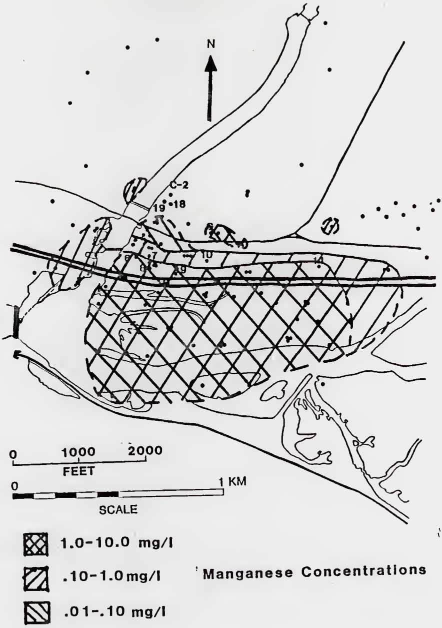


Figure 3.30: Distribution of Mn in the shallow ground water.

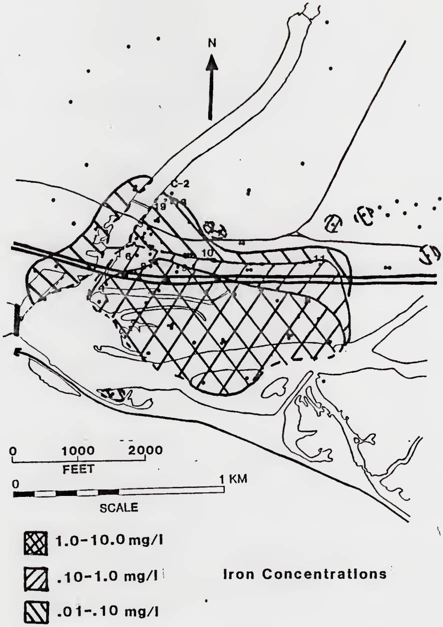


Figure 3.31: Distribution of Fe in the shallow ground water.

interpretation of the three previously discussed components of ground-water flow operating in the study area.

Specialty water quality data were collected in an attempt to better describe the natural hydrogeochemical system operating in the study area. Fifteen samples were run for selenium and mercury; however, all were below detection limits (Appendix D). Analyses for tannin- and lignin-like substances, total organic carbon, nitrates, arsenic speciation, tritium, and deuterium - $^{18}O/^{16}O$ were conducted and a discussion of the results follows.

At the initiation of the project 36 wells were sampled for tannin- and lignin-like substances; later in February 1984, an additional 16 wells were sampled. This sampling was performed to investigate another possible contaminant source: in 1975 ponded log sprinkling water containing organics spilled in the Champion mill property immediately north of wells G and J and a number of other wells. Were organics still in the system, they could be used to trace the flow paths from well G and be used with other data to evaluate the mill as a potential source. A map showing the distribution of tannin- and lignin- like substances in August 1983, is presented in Figure 3.32. Complete tannin and lignin data for this project and previous sampling are presented in Appendix D. The highest concentrations of the constituents are found in wells G, J, 9, 101B, and 6. This distribution suggests that the sources of tannin- and lignin-like substances are still present north of well G and south of well 101B, according to the previous flow direction analysis. With the possible exception of well 10, contaminated wells in the southern portion of the area also contain tannin- and lignin-like substances with levels above background.

Total organic carbon samples were taken in May, 1984, to further characterize the distribution of organic in the ground water (Figure 3.33).

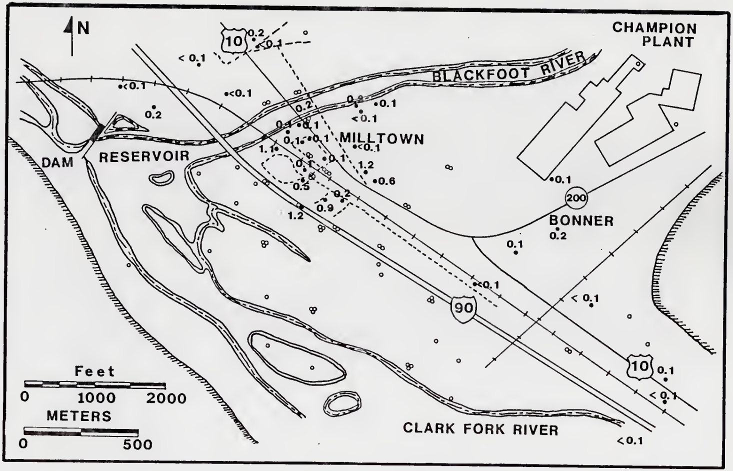


Figure 3.32: Tannin- and lignin-like substances in selected wells (mg/l).

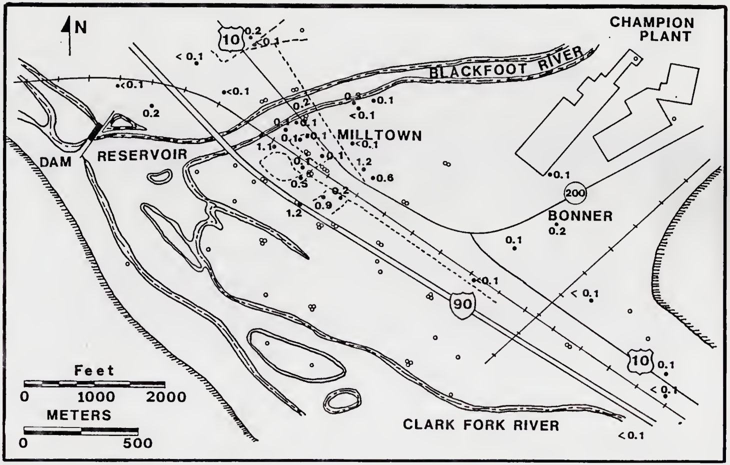


Figure 3.33: Total organic carbon concentrations in selected wells (mg/l)

Dissolved organic carbon in concentrations exceeding 20 mg/l are present in two nests of sandpoints in the reservoir and in well G. Based on the concentrations of the 19 samples (Appendix D), the reservoir sediments and probably a source northeast to north of G appear to contribute organics to the ground-water flow system.

Samples were also taken for nitrate analysis (Appendix D). Results show values were all below 0.7 mg/l. For wells with high iron concentrations values were reported at the detection limit of 0.03 mg/l since iron interferes with the analysis.

Arsenic speciation results are presented in Appendix D. In the majority of cases the dominant species of arsenic was As(III). Wells 10 and 103B lacked As(III) and thus were not dominated by As(III) (Figure 3.34). Samples were also examined for dimethylarsenite, but none was found. In general, the dominance of the water by As(III) probably represents reducing conditions. This would be anticipated in typical ground-water systems and appears to be the case in the reservoir ground-water system and in the area with the contaminated community wells. Ground water at well sites 10 and 103 may represent more oxidizing conditions, as evidenced by lower Fe concentrations.

Tritium and deuterium- $^{18}O/^{16}O$ analyses were performed in the area prior to project well construction to determine if a bedrock component of flow had an isotope signature discernible from that of the alluvial aquifer. Samples from well C2 and 10 finished at the bedrock contact were evaluated in conjunction with those from the shallower alluvial wells and the Clark Fork and Blackfoot rivers. Tritium ranged from 41 to 66 tu for the wells and was 46 tu for the Clark Fork River. Figure 3.35 presents the results of the stable isotope sampling. The close proximity of the values to the meteoric

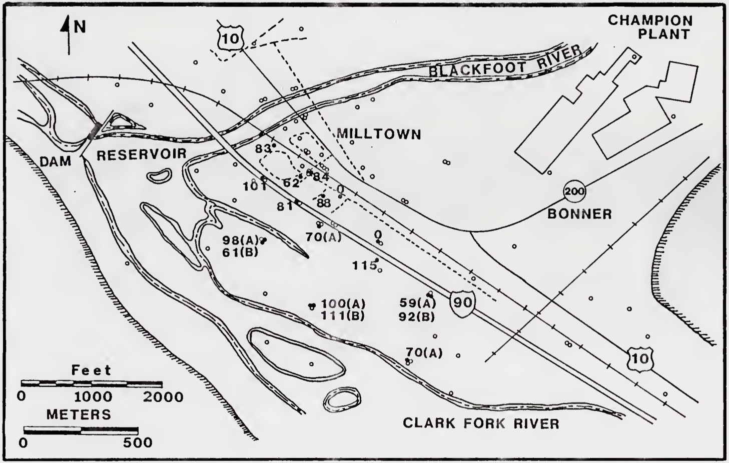


Figure 3.34: Arsenic speciation (As III/ total As) X 100).

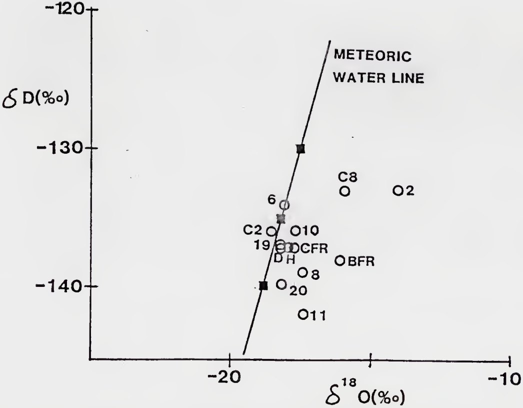


Figure 3.35: Deuterium and ^{18}O in surface water and ground water. Sample locations are indicated on graph.

water line indicates that samples are from the same source. The tritium data for the Clark Fork River and the small range in values for the ground water also indicate the sampled water is derived from the same source. A separate bedrock ground-water system was not discrenible from the isotope data.

Examination of the vertical distribution of constituents in the aquifer was assessed by reviewing the concentrations of As, Mn and TDS at the 15 sites which contained nests of wells (Appendix D). The TDS of the unconfined aquifer increased with depth below the water table at 8 sites, decreased at 6 sites and showed no change at site 106. At the well sites parallel to the reservoir the TDS increased with depth. Wells finished in the reservoir sediments showed a slight TDS increase at sites 122 and 123, and a two times decrease at site 121. Arsenic concentrations decreased with depth below the water table at 4 sites, increased with depth at 5 sites, and showed no change at 6 sites. Arsenic decreases with depth at site 100, 101 and 103 and remains unchanged with depth below the water table at 102. The concentration of As increases with depth at sites 111, 121, 122, and 123 which are located in the reservoir sediment. Manganese concentrations increase with depth below the water table at 2 sites, decrease at 9 sites and show no change at 3 sites. Wells 100, 101, and 103 show a decrease with depth; the concentration does not change with depth below the water table at well 102. Manganese concentrations in the reservoir sediment ground water decrease with depth below the water table.

The distribution of As, Mn and TDS below the water table in the reservoir sediment ground-water system and in the alluvial aquifer directly north and adjacent to the Clark Fork arm of the reservoir is characterized by an increase in the TDS and As with depth below the water table and a decrease of Mn. At well site 107 in the area with contaminated community wells all three constituents increase with depth below the water table. Ground water in the

bedrock at site 107 contains less As and Mn and more TDS than water at the base of the alluvial aquifer. The distribution in the ground-water system associated with Blackfoot recharge, site 106, 108 and 109 is characterized by no change in the arsenic concentrations which are below detection at 108 and 109. Manganese concentrations are below detection at 108, increase with depth at 109 and show little change at 106. TDS increases with depth below the water table at site 108, decreases at 109 and is unchanged at 106.

The preceding maps which summarized the TDS, arsenic, manganese, and iron data only present a small portion of the total chemistry data collected. In an effort to identify the relationship between the concentrations of various constituents, standard correlation coefficients were calculated for chemical constituents with chemical constituents, water table elevation and the discharge of the Clark Fork River for the complete data set, for August-September 1983, and November-December 1983. Appendix D presents all correlations of 0.6 or greater with a significance of 0.1 or less. Good area-wide correlations for arsenic were seen in August-September with Fe (coef.=0.87, n=45), Mn (coef.=0.84, n=44), K (coef.=0.76, n=43), Ca (coef.=0.65, n=43), Mg (coef.=0.61, n=43), HCO_3 (coef.=0.75, n=43), SpC (coef.=0.61, n=41), and TDS (coef.=0.69, n=43). The November-December data, which included project wells, shows arsenic correlated well with Fe (coef.=0.85, n=38), Mn (coef.=0.79, n=38) and Ca (coef.=0.56, n=37). Statistically, when chemical constituents found in the water were correlated with water levels in well 8 or G, only Mn, K, Ca, Mg, and HCO_3 for the August-September data showed any degree of correlation. However, the sample numbers, 4 to 5, are too small for confident correlations. August-September data also correlated poorly with the discharge of the Clark Fork River, as only Fe and Cl showed a correlation greater than 0.58. In lieu of further statistical

examination, the relationships of water table, reservoir stage and Clark Fork River discharge to the concentrations of As, Mn and Fe were evaluated visually by plotting the constituent variation over time and overlaying plots of the three hydrographs. Data for wells 6, 9, G, C2, 99A, 101B, 109B, and 121B are presented in Appendix D. Based on visual inspection, the As concentrations appeared to fluctuate with the water table at well sites 6, 9, G, and C2 and with the Clark Fork River discharge at well G. At C2 data were limited; however an inverse relationship appeared to exist. The fluctuation of arsenic with the river discharge at well site 9 appeared to correlate well until early spring when at high discharge an inverse relationship is apparent. The arsenic concentration at well 9 was the only constituent to show a possible correlation with reservoir stage. Manganese fluctuations correlated with water table changes at well sites 6, 99, and 109B and with river discharge at 6 and G. Manganese concentrations at well site 9 behaved as arsenic concentrations and at well site C2 the concentration change with stage appeared to be an inverse relationship. Iron concentrations correlated with water table fluctuations at well site 6, 101B, and 109B. At sites 6 and G concentrations correlated with river discharge. Concentrations at well C2, again based on limited data, appeared to change inversely with the water table fluctuation.

Acetic acid extracts of soil samples collected in the study area were performed and the results of arsenic analyses are presented in Appendix D. A map generalizing the results is shown in Figure 3.36. The highest concentration found in the soil was near well site 9 in Milltown. This site also has some of the poorest water quality. Concentrations of As were in the 10 to 20 ppm range in areas associated with the Champion log yard and in the reservoir sediments. The high concentration at well 9 probably results from years of watering with contaminated ground water. The higher level in the

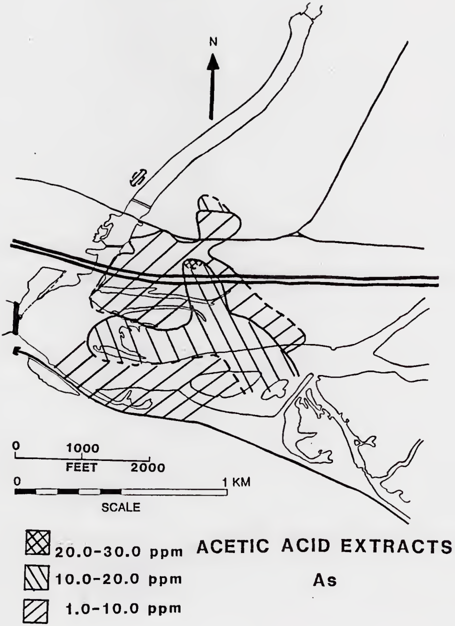


Figure 3.36: Distribution of As in acetic acid extracts for surface soil samples.

sediments is probably related to an arsenic source in the sediments. The high level in the log yard is from an unknown source. Possibly some residual arsenic is present in the soil and summer log spraying with organic-rich water moves some of the metals into the ground water system just north of well G. This could account for the apparently contaminated water at wells G and J.

DISCUSSION, PROBABLE SOURCES OF CONTAMINATION

The head distribution, aquifer geometry, aquifer hydraulic properties, and the presence and distribution of chemical parameters in the ground water system all provide a basis for identifying the source of ground -water pollution occurring in the southern portion of the Milltown area. Four possible sources were originally proposed: 1) an abandoned dump; 2) a deeper bedrock ground-water system; 3) the reservoir sediments and 4) the wood products mill. Each proposed source will be addressed in light of the expanded hydrogeologic data.

The abandoned dump which lies under a portion of the interstate and in part has been placed on top of the existing sediments on the reservoir fringe south of the interstate does not appear to be the source of contamination affecting the Milltown wells. Water quality data for piezometers located near the dump material and well site 102 do not show chemistry that is characteristically different from the entire sediment area. Based partly on the inability to separate effects of the dump from the overwhelming effects of ground-water chemistry of the reservoir sediment, it is not considered a source.

The presence of a bedrock aquifer chemically similar to the ground water found in the contaminated wells was not found. Generally, little water was present in the bedrock and that which was, had a very different chemistry from

the overlying alluvial ground water. Arsenic concentrations were lower in bedrock ground water and strong upward hydraulic gradients were not observed. Tritium and stable isotope data support a young age ground-water system similar in character to the river systems. Thus bedrock is not the source of arsenic contaminating the wells in Milltown.

The movement of ground water in the area and the distribution of metals in the ground water proves the reservoir sediment a likely source of contaminants to the alluvial ground-water system. The water chemistry data generally shows the highest constituent concentrations in the reservoir ground-water, with concentrations decreasing in the direction of flow northward. To further support the concept of the reservoir as a potential source metal contamination, the mass transports of various constituents were calculated for the system through the area of contaminated wells. The calculated discharge from the reservoir, 1,300,000 ft^3/d, was subtracted from the discharge through the contaminated well area, 2,200,000 ft^3/d, and a flow rate of 900,000 ft^3/d was obtained for the component of flow moving parallel to the reservoir and northwest. The average concentrations of As, Fe, Mn, and TDS in the contaminated community well area are 0.15 mg/l, 2.8 mg/l, 3.9 mg/l, and 619 mg/l, respectively. The average concentrations for uncontaminated water moving parallel to the reservoir are 0.005 mg/l, 0.1 mg/l 0.05 mg/l, and 300 mg/l, respectively. The average metal and TDS concentrations in the reservoir ground water are 0.61 mg/l As, 7.7 mg/l Fe, 8.3 mg/l Mn, and 544 mg/l TDS. Subtracting the mass transport associated with uncontaminated flow from the calculated mass transport through the contaminated area, and then dividing by the reservoir ground-water discharge, yields concentrations of average ground water constituent concentrations in the reservoir ground water. The results assume a simple mixing of the 900,000 ft^3/d of uncontaminated water with the water of the reservoir to yield the water quality found in the

contaminated well area. This is an over-simplication of the system and is used as a first approximation only. The values calculated using this method were 0.25 mg/l As, 4.6 mg/l Fe, 6.6 mg/l Mn, and 840 mg/l TDS. Generally, these values agree well with the average values calculated for the reservoir sediment ground water. The TDS values appear high; however, well 121A in the sediment has a TDS of 849 mg/l, so the values does not appear unreasonable for this level of analysis.

Well G is the only contaminated well site not directly or obviously affected by the reservoir source. Based on the potentiometric surface data, the low hydraulic conductivity at 105, the presence of the thin zone of saturation near 104, and the absence of measurable contamination at well sites 99, 105, H, and 17 a second source of contaminations may be present in the area. The possibility that the spill of 1975 was still affecting the well site was also evaluated. The original spill area was approximately 150 ft north of well G. Assuming that the ground-water velocity near the water table at the site is similar to well site 105 (1.9 ft/d), it would have taken only 240 days for the contamination to reach the site. Once the source was removed the majority of the contaminant would have flowed past well G after another 240 days. Thus the effect of the source would have mostly dissipated in less than a year after the source was cleaned up. This analysis requires a number of assumptions: first, the transport of the organics is conservative with no chemical reactions taking place; secondly, the transport is at the same rate as ground-water flow and finally, a fluctuating water table and/or recharge of water from the surface does not remobilize the organics held in the unsaturated zone. If one or all of these assumptions are invalid, then the water quality at well G may reflect remnant contamination. The tannin and lignin data presented in Appendix D shows a concentration of 5.5 mg/l in 1975,

1.3 mg/l in 1982, 1.2 mg/l in 1983, and 0.1 mg/l in 1984 at well G. Further sampling of the well is needed particularly during the time of log sprinkling and later in the fall and winter. If the ground- water velocity is actually more similar to values calculated for sites like 109, then ground-water flowing from north of G would only take a few days to reach well G. Analyses of the data for site G suggests that the source is apparently somewhat localized. The elevated metal level, the high tannin and lignin concentrations and total organic carbon analyses suggest the current Champion log yard operation or the old spill site is a source.

The following section specifically characterizes the reservoir. The distribution of metals and potential for mobility will be discussed.

SEDIMENT GEOCHEMISTRY

SEDIMENTATION AND STRATIGRAPHY

PROCESSES OF SEDIMENTATION

When Milltown Dam was built in 1907 the sediment transport of the Blackfoot and Clark Fork rivers was disrupted. Both bedload and suspended load previously transported westward to the Columbia River was impounded in Milltown Reservoir. This sedimentation has nearly filled the reservoir, so that most of the presentday suspended load of the two rivers passes through the system. This phenomenon, expected because of the small grain size of suspended sediment, is easily demonstrated by the data collected during the Montana Power Company's (MPC) 1980 drawdown to repair the aging dam. Although this data is extremely limited and a true analysis of sediment budget for the reservoir would demand an extensive data gathering effort, it shows the ineffiency of the reservoir to trap suspended sediment even at low flows.

On July 6, 1980, before the reservoir was lowered, the suspended sediment was moving into the reservoir from the Clark Fork and Blackfoot rivers at a rate of 4,065 g/sec (Table 4.1). The output below the reservoir was actually higher, 5,113g/sec. So, even before drawdown the reservoir was transporting all the suspended sediment through the system as well as adding 1,048 g/sec. During the drawdown on July 7, 1980, sediment output from the reservoir increasd dramatically. An excess of nearly 140,000 g/sec of suspended sediment (Table 4.1) was transported out of the reservoir during the drawdown. During one day of the drawdown 12 million kilograms (15,000 tons) of suspended sediment was removed from the reservoir. This output represents approximately 0.2 % of the entire sediment load within the reservoir.

TABLE 4.1

July 7, 1980 Control

	Clark Fork below Milltown	Blackfoot River	Clark Fork at Turah
Discharge:	167,654 l/sec (5,920 cfs)	68,534 l/sec (2,420 cfs)	99,120 l/sec (3,500 cfs)
TSS:	30.5 mg/l	15.5mg/l	30.3 mg/l
Sediment Discharge:	5,113 g/sec	1,062 g/sec	3.003 g/sec

Total input rate: 4,065 g/sec

Total output rate 5,113 g/sec

: Net outflow of 1,048 g sed/sec

July 7, 1980 Drawdown

Discharge:	157,742 l/sec (5,570 cfs)	64,853 l/sec (2,290 cfs)	92,890 l/sec (3,280 cfs)
TSS:	906 mg/l	111.3 mg/l	21.5 mg/l
Sediment Discharge:	142,914 g/sec	545 g/sec	2,387 g/sec

Total input rate: 2,932 g/sec

Total output rate: 142,914 g/sec

: Net outflow of 139,982 g/sec

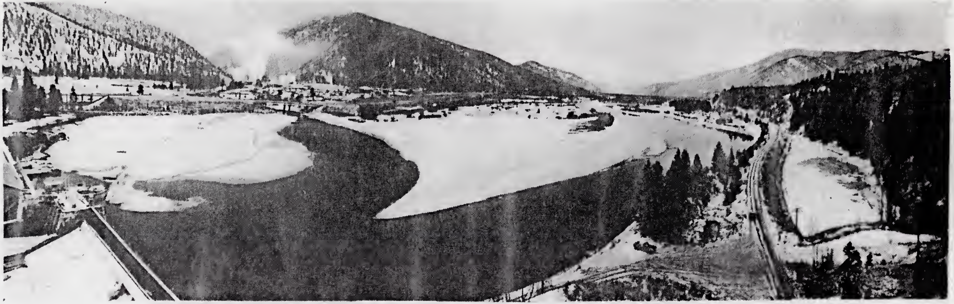


Plate 4.1

Panorama of Milltown Reservoir showing
sediment fill

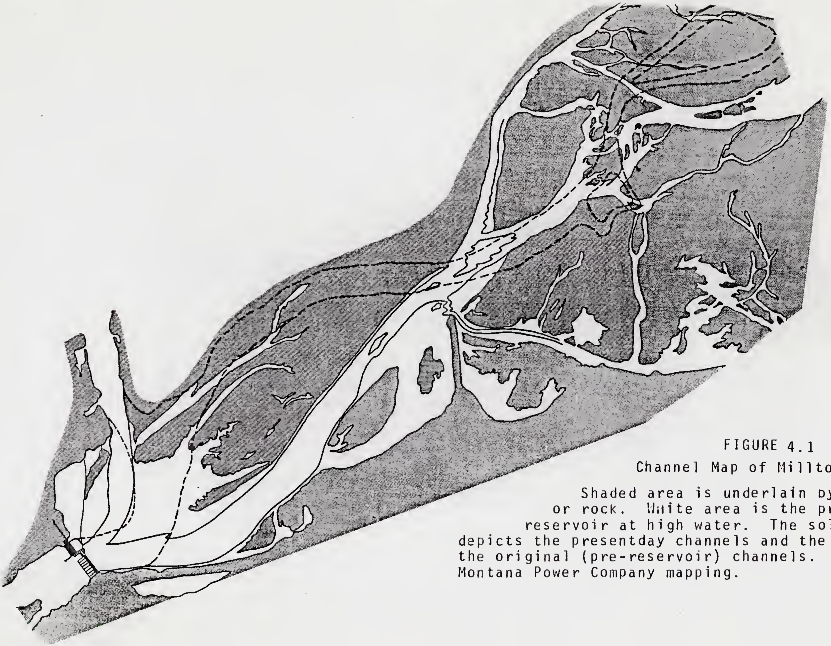


FIGURE 4.1

Channel Map of Milltown Reservoir

Shaded area is underlain by sediment or rock. White area is the present reservoir at high water. The solid line depicts the presentday channels and the dashed line the original (pre-reservoir) channels. Data from Montana Power Company mapping.

The fluvial sedimentation in the reservoir over the last 75 years has resulted in a large mass of bedload sediment migrating towards the dam as the channels shift and change shape. This progradation has resulted in a large sand bar (Plate 4.1) that, at low water levels, separates the flow of the Blackfoot and the Clark Fork rivers near the dam (Figure 4.1). The structure of this bar is complex showing the alternation of sediment transportation and reworking by currents. Layers within the bar dip downstream towards the dam showing the classic construct of deltaic sedimentation (Figure 4.2). Minor muddy layers separate the sand packages showing alternation of bedload and suspended load on the bar. The migration of this deltaic bar and the shifting of the channels in the reservoir, have developed a complex depositional system of channels, floodplain and swamp-filled abandoned channels.

Figure 4.1 shows the actual area covered by water at full pool and the channels revealed at low stands (8 feet below full pool). There is very little storage left for water, and channels from the Blackfoot and the Clark Fork essentially run directly to the dam. Also plotted on figure 4.1 is the location of the original channel before the dam was constructed. The original channel has been completely abandoned and the entire area filled with more recent sediment. The process of sediment buildup in the reservoir is now probably restricted to bedload building the deltaic bar and suspension sediment accumulating on the floodplain. During flooding, vegetation baffles the currents so that the fine sediment can settle out. The import of all these processes is that the reservoir has essentially reached its capacity to hold sediment. It is a storehouse of sediment from upstream and organics produced in the reservoir itself. By making some simple assumptions about the original shape of the river valley before construction of the dam we can therefore estimate the total volume and mass

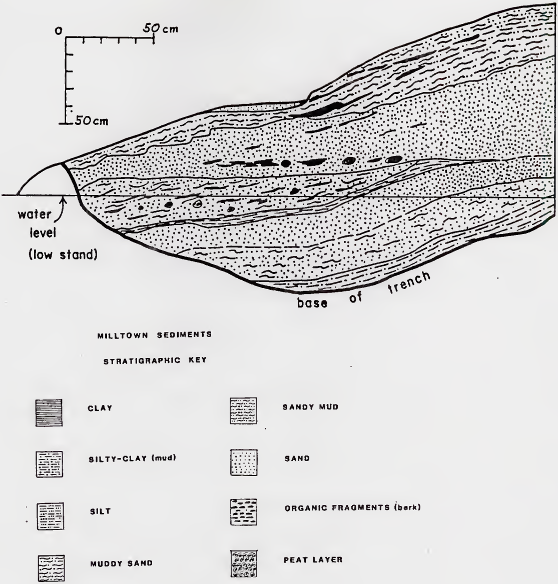


FIGURE 4.2

Profile of a trench dug into the sand bar between the Clark Fork and Blackfoot channels. Scale is one-to-one.

of this sediment stored in the reservoir.

At the dam, the difference in elevation between the reservoir surface and the tailwater at the base of the dam represents the maximum possible sediment thickness. By finding the point where the river still follows its gradient (acts like a river rather than a reservoir) we can identify the upstream position of reservoir sediment accumulation. Using these two limits, the outline of the present reservoir then represents the maximaum area under which sediment can accumulate (Figure 4.3). Admittedly this is an approximate estimate because it does not take into account the irregularity of the channel before reservoir sedimentation. But by removing the volume of water now remaining above the sediment surface (present channels) we can get an "order-of-magnitude" approximation of the volume of sediment residing in the reservoir. This volume is signifiicant: 3.4 million cubic meters of sediment (120 million cubic feet)! Assuming a density of 1.8 g/cc this translates into approximately 6.1×10^{12} grams (6.5 million tons) of sediment. Clearly the reservoir has acted like a sediment trap since its construction.

CHARACTERIZATION OF SEDIMENT

The complex interplay of channels, floodplain and thalweg environments of deposition has created a mosaic of sediment types and grain sizes in the reservoir. Grab samples and cores of the sediment (Figure 4.4) show that the main channels contain the coarsest sediment, and the swampy thalwegs and floodplains are rich in organics and mud. The channel of the Blackfoot River contains very coarse-grained sediment, mostly gravel and cobbles, that could not be sampled. Clay content of the reservoir sediment ranges from 1 to 32% with all the Blackfoot samples containing less than 20% clay with a mean of 10.5 % (Figure 4.5, Table 4.2). Clark Fork arm sediments contain

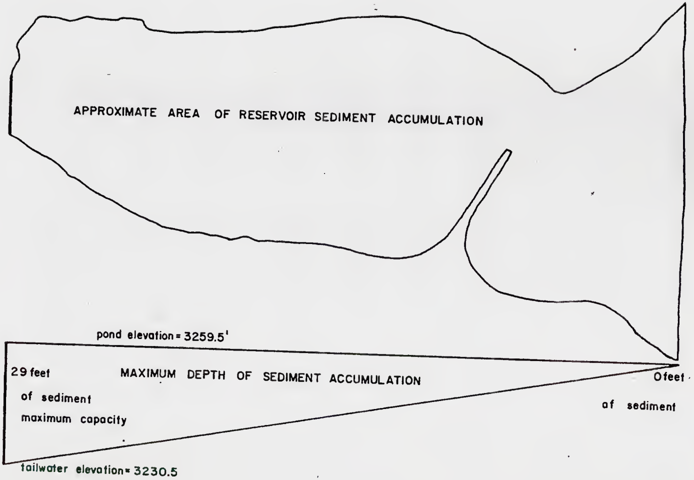

APPROXIMATE AREA OF RESERVOIR SEDIMENT ACCUMULATION
pond elevation = 3259.5'
29 feet
of sediment
maximum capacity
MAXIMUM DEPTH OF SEDIMENT ACCUMULATION
0 feet
of sediment
tailwater elevation = 3230.5

FIGURE 4.3

Approximate Area of Reservoir Sediment Accumulation

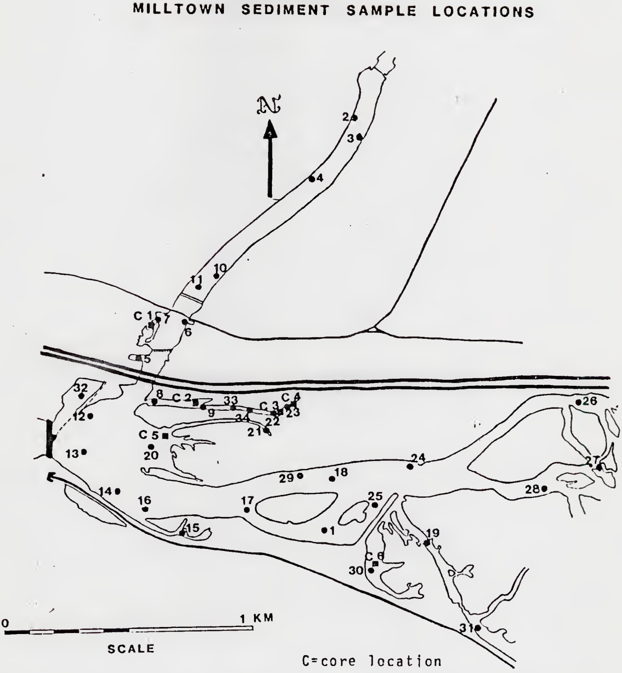


Figure 4.4 : Location of sediment grab sampling sites and sediment core sites.

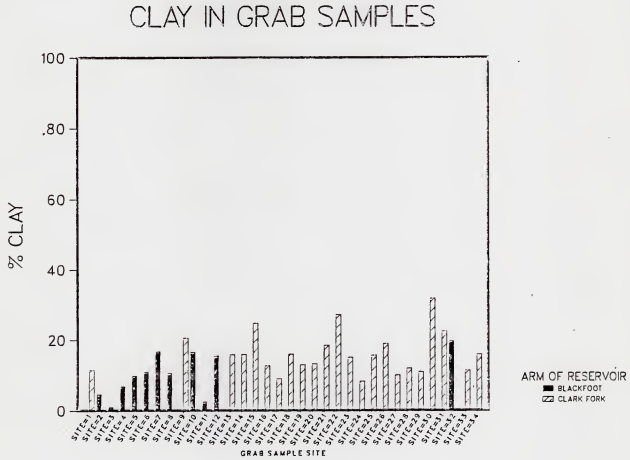

CLAY IN GRAB SAMPLES
100
.80
60
40
20
0
% CLAY
SITE=1
SITE=2
SITE=3
SITE=4
SITE=5
SITE=6
SITE=7
SITE=8
SITE=9
SITE=10
SITE=11
SITE=12
SITE=13
SITE=14
SITE=15
SITE=16
SITE=17
SITE=18
SITE=19
SITE=20
SITE=21
SITE=22
SITE=23
SITE=24
SITE=25
SITE=26
SITE=27
SITE=28
SITE=29
SITE=30
SITE=31
SITE=32
SITE=33
SITE=34
GRAB SAMPLE SITE
ARM OF RESERVOIR
BLACKFOOT
CLARK FORK

FIGURE 4.5

TABLE 4.2

Grain SIze Data for Grab Samples

	Blackfoot Samples			Clark Fork Samples		
	Mean	Std Dev	Range	Mean	Std Dev	Range
Sand:	31.32%	34.38%	1.03-94.3%	31.57%	18.01%	0.81-66.8%
Silt:	58.3%	29.98%	4.66-89.1%	51.9%	15.25%	24.9-85.3%
Clay:	10.47%	6.22%	1.03-19.7%	16.32%	6.7%	8.31-31.89%
Org C:	1.71%	1.00%	0.20-3.7%	2.34	0.73%	0.93-4.52%

from 8 to 30% clay with a mean of 16.3 %. Silt content ranges from 5 to 90 % in the Blackfoot samples and 25 to 85 % in the Clark Fork (Figure 4.6). The mean silt content for Blackfoot sediment is 58.3 % and 51.9 % for the Clark Fork samples (Table 4.2). Sand ranged from 1 to 94 % in the Blackfoot samples and 1 to 67 % in the Clark Fork sediments, with respectiive means of 31.3 and 31.5 % (Figure 4.7). These data show that the Clark Fork surface sediment is somewhat richer in clay than the Blackfoot but the silt and sand percentages are very similar. Grain size analysis of the core samples show a more variable distribution (Table 4.3).

From the standpoint of sediment transport, the percentage of silt and clay in the surface sediment (essentially the suspended load) is very similar for the two areas: 68.8 % mean for the Blackfoot and 68.2 % for the Clark Fork. As well the sand fraction (essentially all bedload transport) is identical: 31.3 % versus 31.6 %. So, the sediment accumulating in the floodplains and abandoned channels (our sampling sites) are very similar texturally in the Blackfoot and Clark Fork arms of the reservoir. As well, the percent organic carbon is very similar but slightly higher in the Clark Fork sediments (Table4.2). Again, at depth in the cores there is much more variation in the grain size (Table 4.3). The core sediments generally show a much finer-grained system, with sand averaging from 10 to 55 %. This variability points up the complexity of this fluvial system.

Six statigraphic cores (Figure 4.4) taken in Milltown reservoir show a complex vertical intermixing of sandy and muddy sediment throughout the reservoir (Figure 4.8). All the cores contain interlayers of sand, mud and clay with isolated concentrations of organic material. Many of the layers have scoured bases indicating reworking and redeposition of sediment. In

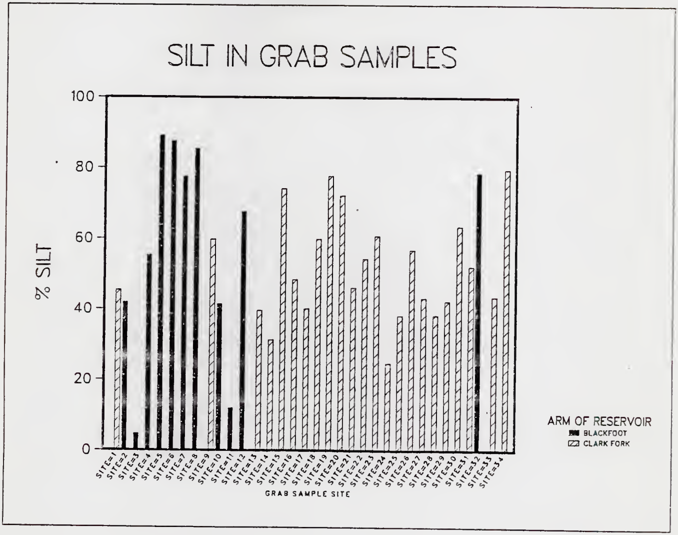
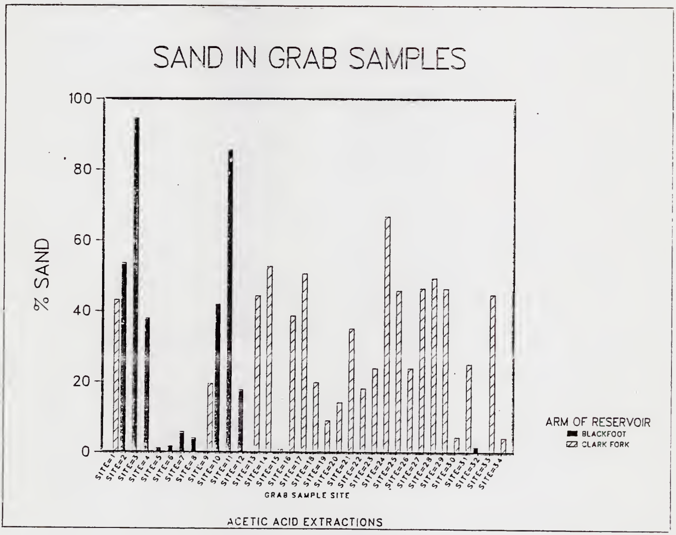

SILT IN GRAB SAMPLES
% SILT
0
20
40
60
80
100
SITE=1
SITE=2
SITE=3
SITE=4
SITE=5
SITE=6
SITE=7
SITE=8
SITE=9
SITE=10
SITE=11
SITE=12
SITE=13
SITE=14
SITE=15
SITE=16
SITE=17
SITE=18
SITE=19
SITE=20
SITE=21
SITE=22
SITE=23
SITE=24
SITE=25
SITE=26
SITE=27
SITE=28
SITE=29
SITE=30
SITE=31
SITE=32
SITE=33
SITE=34
GRAB SAMPLE SITE
ARM OF RESERVOIR
BLACKFOOT
CLARK FORK

FIGURE 4.6


SAND IN GRAB SAMPLES
% SAND
100
80
60
40
20
0
SITE=1
SITE=2
SITE=3
SITE=4
SITE=5
SITE=6
SITE=7
SITE=8
SITE=9
SITE=10
SITE=11
SITE=12
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SITE=24
SITE=25
SITE=26
SITE=27
SITE=28
SITE=29
SITE=30
SITE=31
SITE=32
SITE=33
SITE=34
GRAB SAMPLE SITE
ARM OF RESERVOIR
■ BLACKFOOT
▨ CLARK FORK
ACETIC ACID EXTRACTIONS

FIGURE 4.7

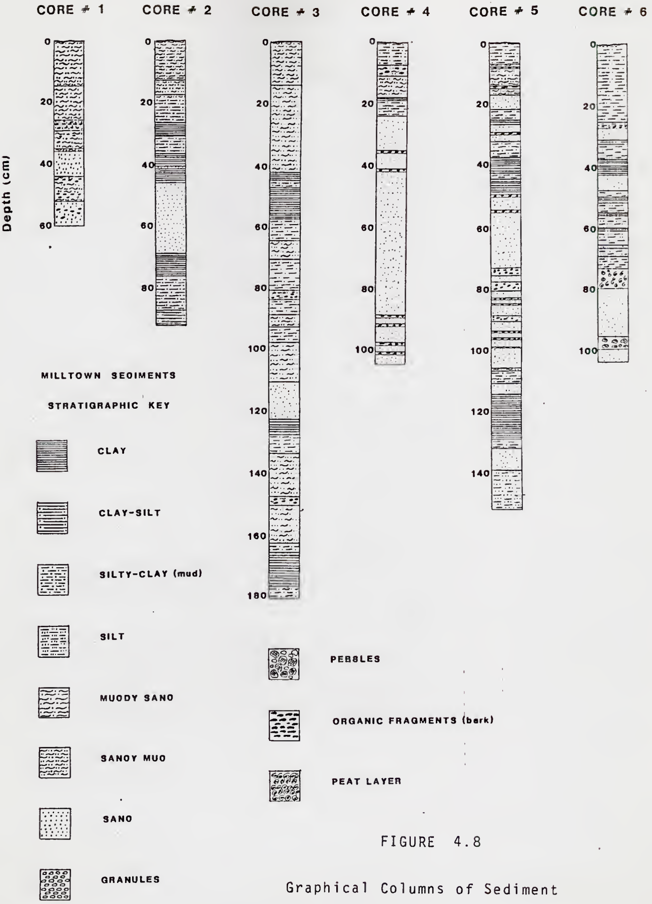

FIGURE 4.8

Graphical Columns of Sediment in Stratigraphic Cores

TABLE 4.3

Grain Size Data for Core Samples

Percent Sand in Cores

Core #	Mean	Std Dev	Minimum	Maximum	n
1	12.27	5.74	6.36	20.14	6
2	50.10	36.13	3.38	85.46	8
3	12.34	7.89	2.82	36.75	15
4	54.76	25.07	8.31	83.10	13
5	25.64	20.98	3.95	69.66	15
6	10.03	12.53	0.51	42.59	11

Percent Silt in Cores

Core #	Mean	Std Dev	Minimum	Maximum	n
1	64.14	4.62	56.81	68.55	6
2	39.13	27.99	11.47	78.37	8
3	67.97	7.28	45.40	77.58	15
4	54.76	25.07	8.31	83.10	13
5	60.23	17.55	24.14	85.42	15
6	66.95	9.13	43.01	75.71	11

Percent Clay in Cores

Core #	Mean	Std Dev	Minimum	Maximum	n
1	23.59	2.03	20.48	26.32	6
2	10.76	8.52	3.07	22.03	8
3	19.69	3.65	11.07	25.42	15
4	11.42	6.76	2.34	24.08	13
5	14.13	5.60	6.20	23.56	15
6	23.02	5.14	14.39	29.34	11

general the upper intervals of the cores are more muddy than the lower intervals but there are no distinct vertical trends that can be correlated from one core to another.

The only distinct layers that can be found in more than one core are some unusual gray layers distinct in cores 2, 3, 5 and 6. Two of these layers, near 40 to 60 cm depth, are clearly correlative throughout the four cores (Figure 4.9). This is unusual because all the other sediment types are so variable. Core 4 does not contain these two layers but does have a thinner gray layer at approximately 20 cm depth which can be correlated to cores 5 and 6 (Figure 4.9). Another similar layer occurs deeper in cores 2, 3 and 5. These gray layers are relatively continuous, and, when the reservoir was lowered could be traced for many meters along exposed banks eroded by both the Clark Fork and Blackfoot channels (Plate 4.2), but the layers do not extend out of the reservoir proper into the Blackfoot arm. In trenches, borings and cuts, up to 4 such layers can be seen, the lowest at a depth of 1.8 m.

Mostly the sediment in cores is sand, muddy sand, sandy mud and mud, distinctly different from the gray layers which are composed of cohesive clay-sized material. The sediments vary from light brown near the surface to gray at depth. This change from oxidizing to reducing environments takes place at a depth of from 15 to 40 cm in the cores. The gray layers are greenish gray when wet, then dry to a very-light gray. They form very sharp contacts with sediment below (Plate 4.3). X-ray diffraction (XRD) analysis of samples from three cores (3, 5 and 6) taken from Milltown reservoir indicate, for the most part, that the sediment contains a diverse but predictable suite of minerals which include quartz, potassium feldspar, plagioclase feldspar, micas, calcite and assorted clay minerals. Clay minerals present include smectites, illite, kaolinite and possibly chlorite.

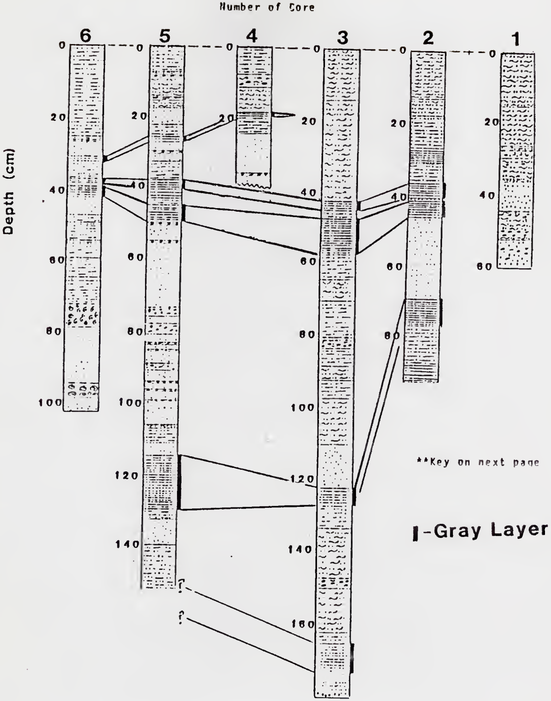

Figure 4.9 Stratigraphy of Milltown Reservoir sediments. (Key on following page)

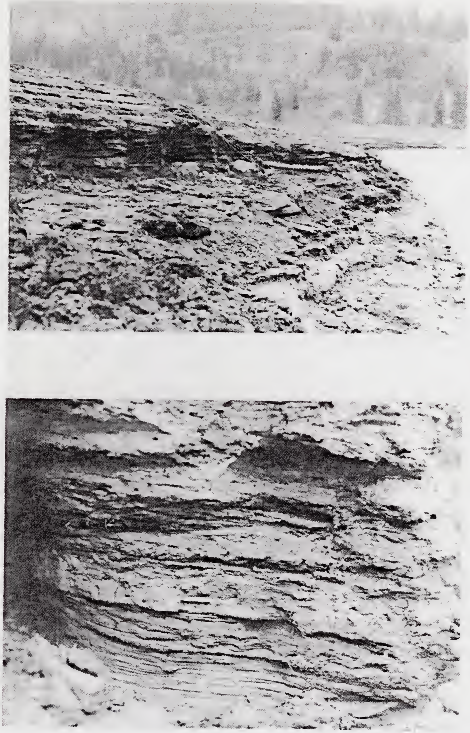

Plate 4.2

Sediment exposed during the winter, 1983-84, drawdown

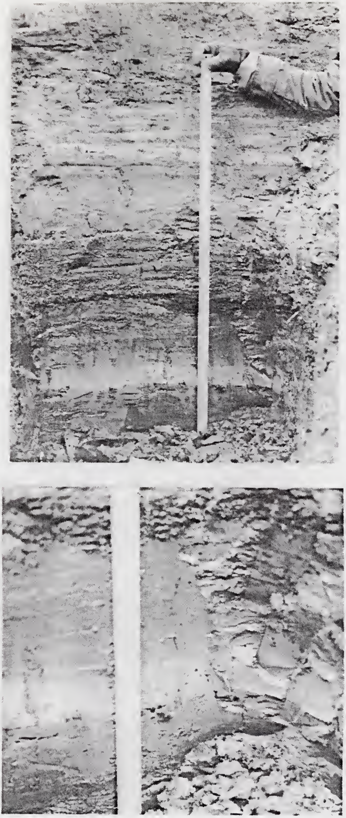

Plate 4.3

Gray layers exposed in trenches cut into Milltown sediment

An exception to this assembalge occurs in the conspicuous gray layers.

The mineralogy of the gray layers is characterized by the presence of very fine-grained micas (i.e., muscovite and/or biotite). Whole-sediment samples contain anomalous amounts of these minerals, and they dominate the mineralogy in the less-than-2-micrometer fraction. Clay minerals such as smectite or kaolinite are entirely absent from the gray layers or present in only very minor amounts.

In XRD analysis, true micas (e.g., muscovite and biotite) are distinguished from the clay mineral illite primarily on the basis of peak "sharpness" and intensity. Both minerals display 10 angstrom peaks, but true mica peaks are sharp and well defined while illite peaks tend to be broader and more diffuse. XRD patterns derived from analysis of whole sediment and the less-than-2-micron fraction of the gray layers are characterized by sharp, intense 10-angstrom peaks.

Figures 4.10, 4.11 and 4.12 illustrate semi-quantitative mineral percentages of samples from cores 3, 5 and 6, respectively. The Figures reveal an increase in the relative amounts of 10 angstrom minerals in the gray layers compared to non-gray layer samples. The sharpness and intensity of the 10 angstrom peaks of the gray layer samples suggests that the difference is due to an increase in the amount of true micas in the sample, that is, very fine-grained muscovite and/or biotite is the major mineral contributing at the 10 angstrom peak.

A sediment composed of nearly all mica is not typical of clay-grained sediment. Compared to the other sediment in the cores the gray layers have a distinct and unusual mineralogy that is quite unnatural. No known natural weathering and erosional processes produce such a mica-rich sediment. However, during the milling of mica-rich igneous rocks, like

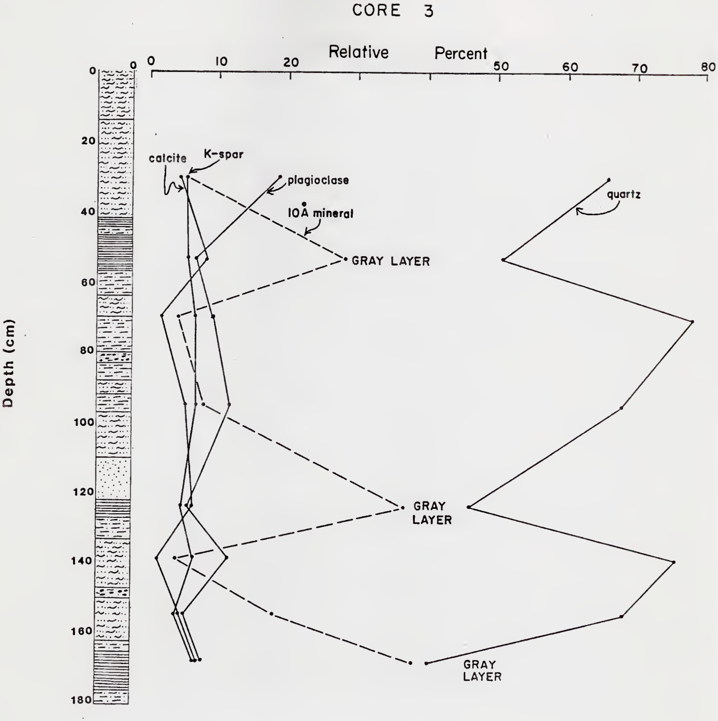

FIGURE 4.10 : Mineralogy of Core 3.

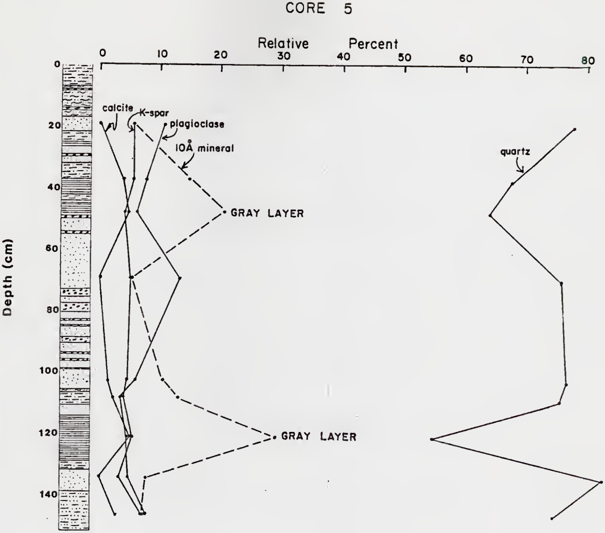

FIGURE 4.11: Mineralogy of core 5.

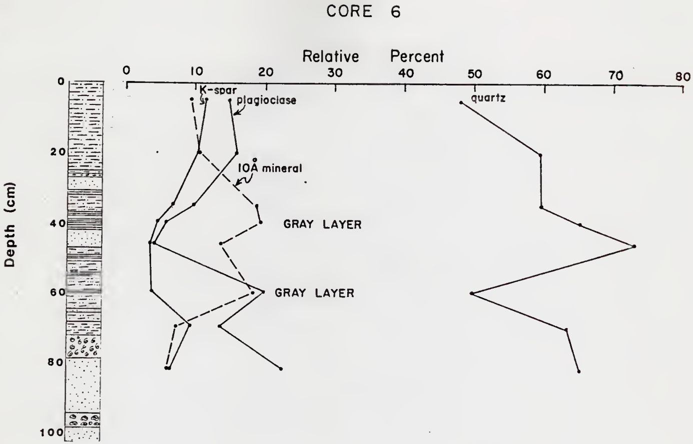

FIGURE 4.12: Mineralogy of core 6.

those mined at Butte, coarse-grained micas are crushed into very fine-grained material which then is easily transported away from the milling site because of its fine-grain size. We think that the gray layers were derived from the Anaconda area and originated as milled quartz-mica porphrys mined in the Butte area. This is supported by the presence of the gray layers only in the Clark Fork arm of the reservoir. As well, because the gray layers cut across other sediment types they apparently came into the system in a catastrophic manner, covering many different environments with up to 10 cm of sediment. Such an event is atypical of all the other sedimentation in the reservoir (the natural fluvial sedimentary processes) and probably resulted from release of millied material during floods or other catastrophic events (e.g., breached or untended settling ponds). If this is the case, then these layers represent something like a set of time lines and could be usful in establishing the history of sedimentation in the reservoir.

DESCRIPTIVE ANALYSIS

GRAB SAMPLES OF SURFACE SEDIMENT

Total Metal Analysis

The total metal contents of surface sediment collected by grab sampler show very distinct lateral variations within the reservoir. Graphic representations of statistical analyses of the data reveal different populations in the Blackfoot and Clark Fork arms of the reservoir (Appendix G). This is well represented by the histograms of arsenic (Figure G1). Total arsenic concentrations in all the Clark Fork samples range from 12.5 to 126 ppm (Table 4.4) with a mean of 58.04 ppm. Blackfooot samples have a mean total arsenic content of only 7.73 ppm and range from 5.5 to 13 ppm, the high reaching only the lowest value recorded from Clark Fork sediment. These different geochemical populations are distinct for manganese, copper, zinc, lead and cadmium (Appendix G; Table 4.4). However, total iron in the surface sediment of the Blackfoot and Clark Fork samples have very similar mean concentrations (Table 4.4) but somewhat different ranges and standard deviations. These two separate sample populations are substantiated by Wilcoxon Rank Sum Tests (Sokal and Rohlf, 1981) which test whether two samples are from the same distribution (Table 4.5). In all cases, except for iron (and sand and silt) the two groups of samples were significantly different.

Within the framework of the two populations there are very distinct variations. Within the Blackfoot, samples are mostly lower than 10 ppm (Figure G1) and only three samples that lie intermediate within the main body of the reservoir (8, 12 and 32, Figure 4.4) contain concentrations of total arsenic approaching the low end of the Clark Fork sediments. Because these three sample sites lie well within influence of the Clark Fork River they are probably best considered intermediate between the two populations. With this consideration then the total arsenic concentration in all the

Table 4.4. Descriptive Statistics for Grab Samples: Totals

Element	Group	Mean	Std. Dev.	Range
As	BF*	7.73	2.078	5.5 - 13
	CF	57.56	23.177	12.5 - 126
Mn	BF	281.36	57.2456	202 - 361
	CF	1290.0	1160.57	455 - 6110
Fe	BF	21163.63	1396.6193	18500 - 23400
	CF	22855.76	5270.9833	15500 - 33200
Cu	BF	40.18	31.266	16.5 - 131
	CF	448.65	177.0202	192 - 939
Zn	BF	127.91	84.2324	60 - 373
	CF	1766.96	1426.8995	623 - 5320
Pb	BF	18.11	5.0735	12 - 26
	CF	67.9615	19.5397	37 - 125
Cd	BF	0.6818	0.4423	0.2 - 1.5
	CF	6.2692	3.7481	2.6 - 16.0

* BF = Blackfoot arm of reservoir
CF = ClarkFork arm of reservoir

Table 4.5. Results of Wilcoxon Rank Sum Test for total metal concentrations in grab samples from Blackfoot arm vs. Clark Fork arm of Milltown Reservoir.

Element	Z (corrected for ties)	2-tailed P
As	-4.7202	0.0000
Mn	-4.7515	0.0000
Fe	-0.0997	0.9206
Cu	-4.7523	0.0000
Zn	-4.7523	0.0000
Pb	-4.7540	0.0000
Cd	-4.7537	0.0000
% Sand	-0.7957	0.4252
% Silt	-1.0633	0.2876
% Clay	-2.1599	0.0308
% Organic Carbon	-2.2158	0.0267

Blackfoot samples is very uniform, ranging from 5.5 to 8 ppm. The total arsenic in the Clark Fork arm sediments is a very different situation where the range is 12.5 to 126 ppm.

Total arsenic in the Clark Fork sediment is clearly concentrated in certain areas. The highest values of total arsenic are found in two sloughs on the south side of the reservoir (sites 15 and 30, Figure G1). As well, the northern slough areas have relatively higher values (sites 21, 23 and 34, Figure G 1). Within this variation, all the samples collected in the Clark Fork arm contain from 2 to 10 times the arsenic found in the Blackfoot sediments.

A nearly identical distribution is seen for total manganese in the surface sediments. The southern and northern sloughs contain very high values of manganese (Figure G2). Iron shows a less variable distribution, substantiating its similarity in all the areas of the reservoir surface sediments. But even though iron concentration does not break out into distinctly different populations, the southern and northern slough areas still have the highest conentrations (Figure G3). The distinction between Blackfoot and Clark Fork samples is well demonstrated by the distribution of total copper in the surface sediment (Figure G4). Most of the Blackfoot samples have less than 30 ppm copper whereas the lowest value in the Clark Fork is 192 ppm copper (Table 4.4). Zinc shows a similar distribution (Figure G5) and both metals show higher concentrations in the northern and southern slough areas as well, especially zinc which reaches values of over 0.5% (5,000 ppm) at site 30 (Figure 4.4). These trends continue for lead and cadmium (Figures G6 and G7). The northern and southern sloughs contain higher values of total metals than the other sites and the Blackfoot sediments are distinctly lower in metal content than the Clark Fork sediments. The highest

values for all metals, except copper, are found at site 30 in the easternmost southern slough (Figures G1 through G7).

Acetic Acid Extraction Analysis

Concentrations of metals in the acetic acid extractions of the surface sediments show grossly similar trends to those seen in the total metals. The most apparent similarity is the division of Blackfoot from Clark Fork sample populations. The acetic-acid extractable arsenic is an excellent example of this division. The Blackfoot sediment contains a mean of only 1.47 ppm arsenic with a range from 0.5 to 5.8 ppm (Table 4.6). As for total arsenic the samples with the higher values are intermediate between the Blackfoot and the Clark Fork arms of the reservoir, so that most of the Blackfoot samples contain less than the minimum value of acetic acid extractable arsenic in the Clark Fork sediment (Figure G8). The Clark Fork sediments contain acetic-acid extractable amounts of from 4.7 to 24.5 ppm, with a mean value of 15.1 ppm, ten times greater than the Blackfoot mean. So, the acetic-acid extracts of the surface sediments also delineate the two populations. This is again substantiated by Wilcoxon Rank Sum Tests. The populations of samples are significantly different for all metals analyzed (Table 4.7), and therefore the two populations are not readily distinguishable. The histograms of the other metals depict these two separate populations of acetic-acid extractable metals, the Clark Fork sediment again containing considerably higher concentrations of metals than the Blackfoot sediment.

As for total arsenic, acetic-acid extractable arsenic is higher in the northern slough area, but some of the southern slough sites (15 and 30) have values below the mean). The variation is much smaller for the acetic acid extractable arsenic than for the total arsenic, though, so that most of the

Table 4.6. Descriptive statistics for grab samples: acetic acid.

Element (ppm)	Group*	Mean	Std. Dev.	Range
As	BF	1.47	1.5043	0.5- 5.8
	CF	15.10	4.4108	4.7- 24.5
Mn	BF	152.7	39.5755	95.0- 230.0
	CF	747.2	435.4544	284.0- 1,730.0
Fe	BF	902.7	164.0320	620.0- 1,200.0
	CF	1,242.	488.5646	580.0- 2,500.0
Cu	BF	9.4	11.9385	4.0- 41.0
	CF	236.5	108.0956	108.0- 555.0
Zn	BF	30.3	59.9074	2.0- 200.0
	CF	1,310	1,074.8809	470.0- 3,560.0
Pb	BF	13.6	4.4578	7.8- 21.0
	CF	24.9	10.6298	10.0- 54.0
Cd	BF	1.2	0.4622	0.5- 2.0
	CF	5.6	3.2254	1.5- 12.5
Ni(ppb)	BF	2,053	1,400.4024	388.0- 5,520.0
	CF	4,794	2,881.7418	1,400.0-10,850.0

* BF = Blackfoot arm of reservoir.
CF = Clark Fork arm of reservoir.

Table 4.7. Results of Wilcoxon Rank Sum Test for metal concentrations in acetic acid extracts from grab samples: Blackfoot vs. Clark Fork arms of Milltown Reservoir.

Element	Z (corrected for ties)	2-Tailed P
As	-4.6207	0.0000
Mn	-4.6568	0.0000
Fe	-2.7428	0.0061
Cu	-4.3432	0.0000
Zn	-4.5068	0.0000
Pb	-3.5757	0.0003
Cd	-4.5387	0.0000
Ni	-3.1109	0.0019

samples cluster near the mean value.

Manganese in acetic acid extractions shows the bimodal distribution between Blackfoot and Clark Fork sediments quite well. Blackfoot sediment contains an average of only 152.7 ppm manganese, whereas Clark Fork samples contain a mean value of 747.2 ppm extractable manganese. The Blackfoot samples have a very narrow range in values (Figure G9), whereas the Clark Fork ranges from 284 to 1730 ppm manganese, with a standard deviation of 435 ppm (Table 4.6).

Mean extractable iron in the surface sediments is somewhat higher in the Clark Fork than in the Blackfoot, 1242.1 ppm versus 902.7 ppm (Table 4.6, Figure G10), but the range of values in the Blackfoot falls within the Clark Fork distribution. The highest extractable iron values are also in the northern and southern slough areas, where concentrations reach over 2,000 ppm.

The distribution of acetic acid extractable copper in the surface sediments clearly demonstrates the separation of the two populations. The Blackfoot samples contain from 4 to 41 ppm copper with a mean value of 9.4 ppm. Clarkfork sediment has an average concentration of 236.5 ppm, with values ranging from 108 to 555 ppm (Figure G11, Table 4.6). The northern and southern sloughs again have the higher concentrations of copper. Extractable zinc is very similar to copper (Figure G12) with extremely high values at sites in the northern and southern sloughs (21, 22, 23, 30, 33 and 34). The Blackfoot samples are barely discernable on the plot because of their extremely low concentrations of extractable zinc.

Concentrations of extractable lead show a less distinct bimodal division between the Blackfoot and Clark Fork samples. Blackfoot sediment contains from 7.8 to 21 ppm lead with a mean of 13.6, whereas the Clark Fork sediment averages 24.9 ppm and concentrations range from 10 to 54 ppm

(Figure G13, Table 4.6). The northern sloughs contain the highest concentrations of lead, and the westernmost southern slough (site 15) also contains relatively high values. But compared to other metals, lead is considerably less variable and more akin to the distribution of iron than the other metals.

Extractable cadmium and nickel (Figures G14 and G15) have distributions somewhat parallel to lead except that the northern and southern sloughs contain the higher concentrations, and site 30 again is amongst the highest values. Mean concentration of cadmium in Blackfoot sediment is 1.2 ppm and 5.6 ppm in the Clark Fork sediment. Nickel concentrations are extremely low, with means of 2053 ppb and 4794 ppb, respectively, in Blackfoot and Clark Fork samples.

All extractable metals, except iron, show the distinct bimodal distribution between the Clark Fork and Blackfoot samples. As for the total metal concentration, extractable metals are highest in the northern and southern sloughs of the Clark Fork arm of the reservoir. The most dramatic enrichment in the Clark Fork over the Blackfoot sediment is for arsenic, manganese, copper and zinc, again mirroring the total metals distributions.

Pore Water Analysis

In general, pore water data is not as clear-cut the total and extractable data. Arsenic in the pore water of surface sediments is essentially the same throughout the reservoir, except for two sites (22 and 23) in the northern slough. Blackfoot samples have a much lower mean value, 0.0058 ppm, than Clark Fork pore water, 0.0507 ppm. Excluding the two high values, all the samples fall below 0.05 ppm, emphasizing the anomaly (Figure G16, Table 4.8).

Table 4.8. Descriptive statistics for grab samples: pore water

Element (ppm)	Group*	Mean	Std. Dev.	Range
As	BF	0.0058	0.0027	0.0024- 0.011
	CF	0.0507	0.0983	0.0019- 0.451
Mn	BF	1.7893	1.4793	0.1240- 4.5
	CF	6.8873	7.1706	0.0000-29.0
Fe	BF	0.3891	0.8530	0.0610- 2.5
	CF	1.9478	3.4980	0.0280-15.0
Cu	BF	0.0092	0.0122	0.0000- 0.032
	CF	0.0087	0.0153	0.0000- 0.064
Zn	BF	0.0465	0.0653	0.0000- 0.177
	CF	0.1916	0.4930	0.0000- 2.7
Pb	BF	0.0058	0.0064	0.0000- 0.015
	CF	0.0019	0.0041	0.0000- 0.017
Cd	BF	0.0013	0.0013	0.0000- 0.0035
	CF	0.0020	0.0035	0.0000- 0.016
Ni	BF	0.0649	0.0354	0.0000- 0.282
	CF	0.0222	0.0050	0.0000- 0.098

* BF = Blackfoot arm of reservoir.
CF = Clark Fork arm of reservoir.

Manganese is more akin to total and extractable data showing somewhat distinct Blackfoot and Clark Fork data sets (Figure G17). Average pore water concentration in the Blackfoot sediment is 1.79 ppm and 6.89 ppm in Clark Fork sediment. However, there is a considerable overlap in the ranges, because the Blackfoot values fall entirely within the Clark Fork range of concentrations (Table 4.8). The Wilcoxon Rank Sum Test for arsenic and manganese show that the two populations are distinct from one another (Table 4.9). All the other metals, except possibly lead, show distributions that fall within one population (Table 4.9).

Although iron appears to fall into a bimodal distribution on the histogram (Figure G18), the extremely high variability (Table 4.8) and the Wilcoxon Rank Sum Test, indicate that the two populations cannot be distinguished from one another. Only four samples in the Clark Fork are above the highest value in the Blackfoot. Iron in the pore water ranges from 0.028 to 15.0 ppm (Table 4.8), with only the four Clark Fork samples above 3 ppm, and all but 1 other (site 3 in the Blackfoot) fall below 2 ppm (Figure G18). The highest pore water iron values are in or near the main Clark Fork channel (sites 1, 28 and 29) at one locality in the northern slough (23). The other sites that coantain high iron in the total and acetic acid extracts have relatively low values of iron in the pore water (e.g., sites 15 and 30).

Copper in the pore water shows essentially no distinct trends. One relatively high value occurs in the northern slough area (site 21) but there is no general trend (Figure G19), and many of the Blackfoot samples contained amounts equivalent to the Clark Fork sediment. Mean values from the two sites are very low and nearly identical, 0.0092 and 0.0087 respectively (Table 4.8).

Zinc in the pore water ranges from 0.000 to 2.700 ppm. The average Blackfoot concentration is 0.0465, and the mean Clark Fork value is 0.1916 ppm (Table 4.8). One anomalously high value of 2.7 ppm zinc occurs at site 21, in

Table 4.9. Results of Wilcoxon Rank Sum Test for metals in pore water of grab samples: Blackfoot vs Clark Fork arms of Milltown Reservoir.

Element	Z (corrected for Ties)	2-Tailed P
As	-3.7973	0.0001
Mn	-2.8048	0.0050
Fe	-1.2891	0.1973
Cu	-0.4387	0.6609
Zn	-1.1694	0.2422
Pb	-2.2147	0.0268
Cd	-0.1377	0.8905
Ni	-0.5457	0.5853

the northern slough area. But all the other values fall below 0.5 ppm (Figure G20). The narrow range and high variability of the other samples demonstrate the lack of discernable trends in the data (Table 4.8).

The very low concentrations of lead in the pore water make interpretaion of the descriptive statistics uncertain. All pore water in surface sediments contained less than 0.017 ppm lead (Table 4.8, Figure G 21). Lead is essentially very low throughout the reservoir. Cadmium and nickel demonstrate similarly low concentrations (Table 4.8), and high variability (Figure G22).

In general the pore water data show variable and relatively low concentrations of metals. Some samples show affinities to trends seen in the total and acetic acid extractable data, but mostly trends are indistinct. There is not a solid distinction between Blackfoot and Clark Fork sediments and the sites that contain very high concentrations of metals in the total and extractable data mostly do not show similar trends in the pore water data.

Distribution and Relative Composition

Chemical analyses of surface sediments show that there are two distinct populations of sediment, one in the Blackfoot arm and one in the Clark Fork arm of the reservoir. This bimodal distribution holds for total arsenic, manganese, copper, zinc, lead, cadmium, organic carbon and percent clay (Table 4.4). Total iron has a similar distribution throughout the reservoir. Acetic acid extractable arsenic, iron, manganese, copper, zinc, lead and cadmium show a similar distribution, iron less significantly than the other metals (Table 4.6). Clark Fork arm surface sediment contains considerably higher amounts of arsenic, manganese, copper, zinc, lead and cadmium in total analyses (Table 4.4). Acetic acid extracts of Clark Fork sediment showed the same enrichment, except that increases in lead and cadmium were not as

distinct (Table 4.6). Iron in both acetic acid extracts and totals does not break out into two distinct populations and has similar distributions throughout the reservoir. Total and extractable metals are common highest in the northern and southern slough areas.

Pore water chemistry shows a less distinct separation of data sets. Only arsenic, manganese and lead show significantly different populations and those are dependent on very high concentrations. In general, pore water has relatively low metal concentrations which likely results from mixing with overlying reservoir water. The trends seen in the total and extractable data are not followed by the pore water data. The northern slough sites continue to display high values of arsenic but most of the other metals do not follow trends seen in the total and extractable fractions.

The relative percentage of total, acetic acid extractable and pore water metals is quite different throughout the samples. Pore water, as expected, forms a very small portion of the metals in the sediment (Figures G 23 to 36, Table 4.10). Acetic acid extractable metals form a significant percentage of the sediment and are quite variable depending on the metal and sediment population (Table 4.10).

Clark Fork sediment contains a much higher percentage of arsenic in the extractable portion of the sediment than does Blackfoot sediment (Figures G23 and G24). Acetic acid extracts of Blackfoot sediment average 16.8 % of the total arsenic, whereas 30.4 % resides in the extractable portion in Clark Fork sediment (Table 4.10). The mean pore water content is approximately 0.1 %. Some of the sites with the highest total arsenic have relatively low values of extractable arsenic (15, 21 and 30, Figure G23). This is likely a result of the lesser variability in the extractable values versus the total concentrations (Tables 4.4 and 4.6).

Relative percentages of extractable and total manganese show somewhat

Table 4.10. Percent of metals held in different fractions: grab samples.

Element	Group*	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
As	BF	83.03 (10.55) (55.42-91.85)	16.85 (10.540) (8.11- 44.51)	0.120 (0.110) (0.03-0.43)
	CF	68.80 (13.68) (27.98-94.85)	13.68 (13.13) (13.13- 71.92)	0.100 (0.230) (0.00-1.09)
Mn	BF	44.82 (8.87) (27.76-56.42)	54.54 (8.71) (43.42- 70.65)	0.700 (0.620) (0.05-1.77)
	CF	35.93 (21.82) (0.00-91.60)	63.28 (21.62) (8.29- 99.56)	0.790 (0.890) (0.00-3.66)
Fe	BF	95.90 (0.93) (94.82-97.86)	4.10 (0.928) (2.14- 5.18)	0.002 (0.004) (0.00-0.01)
	CF	94.59 (2.05) (88.42-96.58)	5.4 (2.04) (3.41- 11.52)	0.008 (0.016) (0.00-0.00
Cu	BF	82.24 (17.73) (68.70-89.72)	17.73 (6.72) (10.26- 31.30)	0.035 (0.054) (0.00-0.16)
	CF	48.76 (14.64) (5.61-81.61)	51.24 (14.64) (18.39-94.39)	0.003 (0.005) (0.00-0.01)
Zn	BF	85.12 (14.05) (46.38-97.79)	14.84 (14.07) (2.13-53.62)	0.050 (0.077) (0.00-0.24)
	CF	29.52 (14.73) (0.00-66.01)	70.49 (14.73) (33.99-100.00)	0.009 (0.016) (0.00-0.06)
Pb	BF	25.56 (9.43) (16.00-41.33)	74.41 (9.44) (58.67- 83.99)	0.032 (0.046) (0.00-0.11)
	CF	62.18 (13.57) (30.77-90.40)	37.82 (13.57) (9.60- 69.22)	0.003 (0.008) (0.00-0.03)

* BF = Blackfoot arm of reservoir.
CF = Clark Fork arm of reservoir.

analogous trends but of very different magnitudes. Blackfoot sediment contains from 43.4 to 70.7 % extractable manganese, with a mean value of 54.5% and a relatively low variability (Table 4.10, Figure G26). Clark Fork sediments show a much greater variability ranging from 8.3 to 99.6 % extractable manganese, with a mean value of 63.3 % and a considerably larger variability (Table 4.10). The Clark Fork samples which have lower total values have relatively higher extractable values, and the samples with higher total values have relatively lower percentages of extractable manganese. Pore water contains nearly 1 % of the total manganese in the surface sediments, with a maximum of 3.7 % in Clark Fork samples and 1.8 % in Blackfoot samples.

Extractable iron makes up only a small percentage of the total iron in the sediment (Table 4.10, Figures G27 and G28). The Blackfoot values are relatively constant containing an average of 4.1 % extractable iron, with very low variability. Clark Fork sediment shows more variability with mean values of 5.4 % extractable iron. There is a fairly straight-forward relationship between extractable and total iron, higher total values contain more extractable iron. Pore water contains only a very small percentage of the total iron in the surface sediments, less than 0.01 %.

Extractable copper in the Clark Fork samples contain greater than 90 % extractable copper. The variability of percent extactable copper is relatively low and it results almost entirely from two samples (23 and 33, Figure G29). There is no obvious connection between high total and relative percentage of extractable copper. Pore water contains only approximately 0.03 % of the total copper.

There is a clear division between Clark Fork and Blackfoot samples in relative percentage of extractable zinc (Table 4.10, Figures G31 and G32). Blackfoot samples contain only 14.8 % extractable zinc with a high variability

caused by one sample (the intermediate site, 8). The Clark Fork samples contain an average of 70.5 % extractable zinc, and most of the samples with higher concentrations of total metals have a relatively lower percentage of extractable zinc (Figure G31). However the Blackfoot sediment has a higher percentage of zinc in the pore water, averaging 0.05 % compared to a miniscule 0.009 % for the Clark Fork.

Lead shows some very different relationships than all the other metals. The Blackfoot samples are essentially entirely extractable lead, whereas the Clark Fork samples contain from 9.6 to 69.2 % extractable lead, with a mean of 37.8 % (Table 4.10, Figures G33 and G34). Cadmium has similarly odd distribution with very high variability and percentage of extractable metal (Figures G35 and G36). Many of the samples contained a larger portion of extractable cadmium than total metals indicating the preparations did not proceed in the expected manner.

For all the samples it is clear from the above descriptions that a large proportion of all the metals, except iron, are found in acetic acid extractable forms. Pore water generally contains a very small percentage of the total metals except for manganese where it reaches a few percent.

CORE SAMPLES OF SEDIMENTS

Total Metal Analysis

Total metal analysis of samples taken from cores at 10 cm depths within the reservoir sediment show very different amounts of metals than the surface sediments.

The division between Clark Fork and Blackfoot samples as seen in the surface sediments, is very apparent in the core data. Core 1, from the Blackfoot arm of the reservoir shows essentially no variation in

metal content with depth. All the Clark Fork cores (2 to 6) contain very different concentrations of metals with depth. These trends are well illustrated by arsenic.

Arsenic in core 1 remains very low from the surface to the lowest sample taken, averaging 12.8 ppm (Figure G37, Table 4.11). All the Clark Fork cores contain much more arsenic with depth with the mean values, ranging from 112.8 to 669 ppm, much greater than the surface sediment total arsenic (Figure G38 to G42). Core 3 shows the most dramatic increase with depth where total arsenic reaches values of 1590 ppm at 78 cm below the surface, and nearly 1500 ppm at 148 cm (Figure G39). Core 3 in the northern slough and core 6 in the eastern southern slough contain by far the highest concentrations of total arsenic.

Manganese also show enrichment downwards in the sediment (Figures G43 to G48). Core 1, in the Blackfoot arm, shows only a small variation around the mean value of 254.6 ppm (Table 4.11), but some Clark Fork cores show dramatic increases. Core 3 has a mean value of 1937.9 ppm total manganese but samples from 28 cm depth contain 3150 ppm manganese (Figure G45). Core 6 shows similar trends (Figure G48). Other cores show very high surface values that decrease with depth. The top of core 5 contains 4010 ppm manganese, well above the mean of 1694.9 ppm (Figure G47). Cores 2 and 4 show similar trends (Figures G 44 and G46).

As for arsenic and manganese, iron stays relatively constant in the Blackfoot core (Figure G49, Table 4.11) where the maximum value 22,100 ppm at the surface is near the mean of 19,466 ppm total iron. Cores 2, 4 and 5 have the highest values near the top of the core (Figures G50, G52 and G53) and then iron decreases with depth to nearly one-half the maximum values. Core 3 shows a relatively high, but low variability, total iron content with the lowest value at the top (Figure G51). Core 6 continues to

Table 4.11. Arsenic in total extractions from cores (all values expressed as ug As/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	6.42	1.02	5.	8.00	6
2	112.78	107.19	35.	350.00	9
3	660.00	498.12	84.0	1590.00	16
4	181.92	164.03	21.0	469.00	13
5	180.40	101.29	60.00	387.00	15
6	466.00	356.64	101.00	1420.00	11

Table 4.11 continued. Manganese in total extractions from cores (all values expressed as ug Mn/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	254.67	58.38	195	367	6
2	991.00	489.67	431	1450	9
3	1937.88	596.24	1044	3150	16
4	1294.08	658.98	530	2690	12
5	1694.93	970.69	650	4010	15
6	2324.73	1038.62	560	3410	11

Table 4.11 continued. Iron in total extractions from cores (all values expressed as ug Fe/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	19466.67	2310.56	16000	22100	6
2	23266.67	12374.98	11200	42500	9
3	27737.50	4161.87	16900	36800	16
4	19541.67	6179.65	11900	35200	12
5	20973.33	6473.62	13600	37900	15
6	31527.27	9404.37	22000	53200	11

Table 4.11 continued. Copper in total extractions from cores (all values expressed as ug Cu/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	36.53	6.11	30.3	45	6
2	885.44	928.25	210	2370	9
3	4540.31	3216.48	1050	10800	16
4	1257.38	1083.57	213	3700	13
5	1423.67	717.18	560	2800	15
6	2803.00	2088.38	644	7985	11

Table 4.11 continued. Zinc in total extractions from cores (all values expressed as ug Zn/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	52.00	15.85	34	80	6
2	3088.67	3583.68	383	9930	9
3	6437.19	2332.22	2230	10900	16
4	2387.08	1831.03	523	6280	12
5	2834.67	2122.19	1050	9330	15
6	5475.00	2797.91	2440	11200	11

Table 4.11 continued. Lead in total extractions from cores (all values expressed as ug Pb/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	19.00	3.24	15	24	6
2	151.89	169.98	43	497	9
3	413.87	294.33	108	900	15
4	201.31	201.02	43	677	13
5	203.00	130.72	90	513	15
6	339.73	246.74	83	733	11

Table 4.11 continued. Cadmium in total extractions from cores (all values expressed as ug Cd/g dry wt. sediment).

Core#	Mean	Std. Dev.	Minimum	Maximum	n
1	0.98	0.21	0.046	1.3	6
2	8.93	8.95	1.6	25	9
3	25.19	10.02	12.	45	16
4	8.75	4.92	2.0	18	13
5	10.15	5.79	3.6	27	14
6	21.33	12.95	3.6	53	11

show highly elevated metal contents with depth, where at 30 cm the sediment contains 53,200 ppm total iron, well above the mean of 31,527 ppm (Figure G54).

As for all the metals previously discussed, copper is low in the Blackfoot core and remains fairly constant with depth (Table 4.11). But the Clark Fork cores show significant increases with depth over the surface sediment. All five cores have concentrations at depth considerably higher than the average values (Figures G55 to G59, Table 4.11). Core 3, from the northern slough, shows the largest increase, where at a depth of 78 cm total copper is 10,800 ppm, well above the average of 4540 ppm and the surface values 1500 ppm. Core 6 also shows an extreme increase with depth where the 80 cm deep sample contains 7,985 ppm copper and the surface sample only 644 ppm. Cores 2 and 5 show relatively low concentrations of copper that are somewhat less variable with depth.

Zinc in the Blackfoot core is quite low, 52 ppm average, and remains low with depth (Table 4.11), but all but one of Clark Fork cores contain significantly higher values at depth (Figures G60 to G64). Values in cores 3, 5 and 6 reach near or over 10,000 ppm at depth. Core 3 samples reach 10,900 ppm at 138 cm depth, well above the mean value of 6,437 ppm total zinc and the surface value of only 2,230 ppm. Core 6 contains 11,200 ppm zinc at 30 cm depth and only about 3,000 ppm at the surface. Core 4 shows the highest values at the surface.

As for all the other metals, total lead in core 1 is very low and relatively constant with depth (Table 4.11). All the other cores show increases in total lead with depth (Figures G65 to G69). Again, cores 3 and 6 have the most dramatic enrichment with depth. Core 3 contains only 108 ppm total lead in the upper 18 cm but reaches 900 ppm at 68 cm and 138

cm, averaging 413.9 ppm. All the Clark Fork cores show values at depth that are from five to nine times the surface concentration and well above the average for the cores.

Cadmium is insignificant in the Blackfoot core (Table 4.11) averaging less than 1 ppm, but it reaches values near or greater than 20 ppm in all the Clark Fork cores (Figures G70 to G74). Core 3 contains a maximum of 45 ppm cadmium at 88 cm depth, well above the average value of 25.2 ppm total cadmium. Core 6 contains a maximum value of 53 ppm cadmium and a mean of 21.3. The increases in cadmium concentration with depth are substantial but not nearly as dramatic as for other metals.

Acetic Acid Extraction Analysis

All the acetic acid extraction data show somewhat similar trends in distribution and concentration as for total metals in cores. Core 1, from the Blackfoot, always contains very low concentrations of metals which are relatively constant with depth. Generally, metal concentration increases below the surface in the Clark Fork cores and areas that contain high total values also contain high extractable values, but there are some exceptions.

Arsenic shows the Blackfoot-Clark Fork division very well (Table 4.12, Figures G75 to G80). Core 1 contains only an average of 0.51 ppm extractable arsenic while cores 2 to 6 contains mean values of from 22.54 to 84.22 ppm. Core 3 contains a maximum content of extractable arsenic at 88 cm depth, 120 ppm, two times the mean value of 54.74 ppm. Cores 4, 5 and 6 have similar concentrations, reaching maximum values of 120, 138 and 146 ppm extractable arsenic, all above the surface sediment and mean values.

Manganese shows a very different trend than arsenic. Most cores have higher concentrations of extractable manganese near the surface that decrease with depth (Figures G81 to G86), but cores 2, 3 and 6 have higher values below

the surface sediment. Core 3 contains 2400 ppm extractable manganese at 28 cm depth, considerably higher than the 1500 ppm at the surface and 1,090 ppm mean value. The zone from 10 to 40 cm depth in core 6 contains a higher concentration than the surface sediment, but the values decrease below 40 cm. Core 2 shows a similar trend with depth.

Acetic acid extractable iron has a distribution in the cores very different that that seen for manganese (Figures G87 to G92). In the Blackfoot, iron is low and relatively constant with depth, as usual, with a mean of 501.7 ppm and a maximum at the surface of 800 ppm. All the Clark Fork cores have contents of iron five to eleven times the Blackfoot. Cores 2, 3 and 6 contain the highest concentration of extractable iron at depth, with maximums of 17,600, 17,980 ppm and 13,646 ppm respectively. Core 5 contains a much less variable distribution of extractable iron than the other Clark Fork cores and a mean of only 5,500 ppm.

Extractable copper is very low in core 1 (Table 4.12) and quite high in all the other cores. Even core 2, which is commonly intermediate between the Blackfoot core and the Clark Fork samples, has a mean concentration of 640 ppm and a maximum value at 27 cm of 1,840 ppm extractable copper. The only higher value, 1900 ppm, is found in core 3 at a depth of 78 cm (Figures G93 to G97). Core 3 has an average compostion of 1002.3 ppm, much greater than the other cores. All the cores show a significant increase in copper with depth. Core 6 has a surface content of only 100 ppm extractable copper but increases to 1,660 ppm at 80 cm depth.

The mean concentration of extractable zinc in core 1 is 11.7 ppm but ranges from 1,104 to 2,545 ppm in the Clark Fork cores, again demonstrating the vastly different populations (Table 4.12). All the Clark Fork cores contain samples that approach 5,000 to 6,000 ppm (Figures G98 to G102). Core

Table 4.12. Arsenic in acetic acid extracts of cores (all values expressed as ug As/g dry wt. of sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.51	0.51	0.19	1.42	6
2	22.54	21.18	8.02	76	9
3	54.74	30.75	22.00	120	16
4	49.01	46.29	5.42	138	13
5	23.25	17.30	6.00	66	15
6	84.22	40.72	11.40	146	11

Table 4.12 continued. Manganese in acetic acid extracts of cores (all values expressed as ug Mn/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	64.00	28.34	38	104	6
2	745.78	535.76	174	1460	9
3	1090.62	529.92	380	2400	16
4	705.69	452.92	194	1820	13
5	486.13	275.85	48	940	15
6	1244.09	779.08	260	2200	11

Table 4.12 continued. Iron in acetic acid extracts of cores (all values expressed as ug Fe/g [illegible] wt. sediment.

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	501.67	206.15	250	800	6
2	4686.67	5763.37	940	17600	9
3	5068.00	4245.18	2000	17980	15
4	3170.77	2282.38	240	7980	13
5	2224.00	1298.88	720	5500	15
6	6289.09	4507.63	1000	136460	11

Table 4.12 continued. Copper in acetic acid extracts of cores (all values expressed as ug Cu/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	6.33	0.82	6.0	8.0	6
2	640.67	733.08	138	1840	9
3	1002.31	389.40	560	1900	16
4	493.69	400.34	94	1220	13
5	594.27	345.52	90	1100	15
6	713.18	631.32	100	1660	11

Table 4.12 continued. Zinc in acetic acid extracts of cores (all values expressed as ug Zn/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	11.67	11.96	6.0	36	6
2	1883.33	2196.41	320	6120	9
3	2391.25	1681.97	440	5420	16
4	1500.0	1417.56	380	4920	13
5	1104.0	1445.71	280	5860	15
6	2544.54	1887.56	170	5780	11

Table 4.12 continued. Lead in acetic acid extracts of cores (all values expressed as ug Pb/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	18.00	0.00	18	18	6
2	70.78	90.99	23	299	9
3	162.43	103.60	53	359	14
4	109.62	122.02	27	399	13
5	79.46	48.83	23	183	13
6	139.36	112.88	19	299	11

Table 4.12 continued. Cadmium in acetic acid extracts of cores (all values expressed as ug Cd/g dry wt. sediment).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	1.17	0.41	1.0	2.0	6
2	7.78	8.50	1.0	24	9
3	11.50	6.04	4.0	22	16
4	6.00	4.08	2.0	16	13
5	6.13	6.30	2.0	26	15
6	9.76	5.76	2.0	22	11

4 shows a decreasing downward trend that is similar in core 5. Cores 2, 3 and 6 have increase from the uppermost sediment to a maximum at approximately 20 cm depth.

Lead is a constant 18 ppm in core 1 and the mean content ranges from 70.8 to 162.4 ppm in the other cores (Table 4.12). Extractable lead, in general, is lowest at the surface and increases with depth (Figures G103 to G106). The highest values are in core 6 at a depth of 80 cm. Cadmium shows a nearly opposite trend with the samples near the surface containing the higher concentrations. The Blackfoot core is again low and constant (Table 4.12) and the Clark Fork cores showing somewhat higher values which decrease with depth, generally (Figures G107 to G112). Compared to many of the other extractable metals (e.g., zinc, manganese, copper and arsenic) cadmium shows fairly minor enrichment with depth in the cores.

Pore Water Analysis

Pore water in the cores contains variable quantities of metals and shows some affinities to the trends seen in the extractable and total metals. The main separation between Clark Fork and Blackfoot sediment is still very pronounced, all the Clark Fork samples containing significantly greater amounts of metals.

Pore water arsenic in the cores shows a large variation between sites and with depth (Figures G113 to G117). Core 6 contains up to 8 ppm arsenic at a depth of 70 cm, but has less than 0.05 ppm at the surface, and a mean value of 2.2 ppm (Table 4.13). Cores 2, 4 and 5 have concentrations mostly less than 2 ppm, but with quite a bit of variability. Core 3 shows relatively high concentrations near the surface, 4 to 5 ppm, but decreases to less than 0.5 ppm at depth.

Manganese in core pore water is quite variable (Table 4.13). Core 1

Table 4.13. Arsenic in core pore water (all values expressed as mg As/l).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.005	0.000	0.005	0.005	4
2	0.346	0.334	0.019	0.888	9
3	1.001	1.514	0.046	5.100	16
4	0.523	0.556	0.049	1.600	13
5	0.609	0.649	0.024	2.600	15
6	3.666	2.501	0.028	7.900	11

Table 4.13 continued. Manganese in core pore water (all values expressed as mg Mn/l).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.000	0.000	0.000	0.000	4
2	8.311	3.958	0.800	13.000	9
3	15.888	9.400	4.900	39.000	16
4	26.238	32.294	1.900	117.000	13
5	25.813	23.716	1.400	104.000	15
6	8.627	7.058	1.200	23.000	11

Table 4.13 continued. Iron in core pore water
(all values expressed as mg Fe/l

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.167	0.214	0.009	0.463	4
2	15.164	17.948	0.478	48.000	9
3	47.613	47.714	3.400	198.000	16
4	67.077	116.085	3.400	434.000	13
5	92.360	152.458	0.900	592.000	15
6	55.636	32.182	17.000	113.000	11

Table 4.13 continued. Copper in core pore water
(all values expressed as mg Cu/l).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.000	0.000	0.000	0.000	4
2	2.589	4.113	0.025	13.000	9
3	0.132	0.184	0.000	0.600	16
4	0.720	1.613	0.000	4.800	13
5	3.450	5.844	0.006	23.000	15
6	0.704	1.045	0.000	3.400	11

Table 4.13 continued. Zinc in core pore water (all values expressed as mg Zn/l).

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	0.000	0.000	0.000	0.000	4
2	7.600	9.014	0.300	28.000	9
3	4.144	4.359	0.700	15.000	16
4	13.315	23.007	0.100	83.000	13
5	10.987	11.057	0.006	23.000	15
6	3.327	2.380	0.400	8.500	11

again contains very low values compared to Clark Fork sediment and core 2 has relatively constant concentration of manganese in the pore water with depth (Figures G118 to G122), mostly below 15 ppm. Core 3 also shows low variability but concentration decreases somewhat with depth (Figure G119). Core 6 has a slightly similar trend (Figure G122). The highest values occur in cores 4 and 5, both at approximately 120 cm depth, 120 and 105 ppm respectively (Figures G120 and 121). Core 4 is the only core that shows relatively high values near the surface, approximately 50 ppm above 50 cm.

Iron shows similar trends to manganese in the pore water (Table 4.13, Figures G123 to G1278). The highest values are in cores 4 and 5 at a depth of approximately 120 cm. The iron in core 6 pore water increases with depth from 20 ppm at the surface to 100 ppm at 100 cm.

Copper in pore water from core 1 is essentially undetectable and core 3 contains a mean concetration of only 0.13 ppm, much lower than all the other Clark Fork cores (Table 4.13, Figures G128 to G131). Core 6 also contains very low concentrations of copper, with a mean of only 0.70 ppm. Core 5 has the largest values of copper in pore water, averaging 3.45 ppm amd ranging up to 23.0 ppm at a depth of 22 cm. Core 2 has one sample with 13.0 ppm, but in general, copper is quite low in the pore water of the cores.

Core pore water from Clark Fork sediment contains a fair quantity of zinc (Table 4.13, Figures G132 to G136). Mean concentrations for zinc range from 4.14 to 13.32 ppm, with the highest values in core 4. Cores 4 and 5 show values above the mean above 60 cm and below 120 cm depth. Core 6 contains relatively low values. Core 2 reaches values of 28 ppm at a depth of 27 cm.

In general, pore water metals are quite variable and occur in relatively low concentrations. There is little similarity between trends

seen for total and extractable metals and those in the pore water.

Distribution and Relative Composition

The division between Clark Fork sediment and Blackfoot sediment continues to hold for metals in cores. In all cases the concentration in pore water from the Blackfoot is so low that it is commonly undetectable. The northern and southern sloughs contain higher concnetrations of total and extractable metals but pore water values do not generally follow that trend. The relative percentages of acetic acid extractable and pore water metals of the total content is quite variable, depending on metal type and location.

Extractable arsenic in core samples from the Blackfoot represent, on the average, only 3.81 % of the total arsenic (Table 4.14). This is a very small percentage compared to the Clark Fork sediment where mean extractable arsenic ranges from 13.40 to 27.17 % (Figures G137 to G142). Cores that have high total concentrations of arsenic have the largest variability (e.g, cores 3 and 6) because the absolute extractable arsenic remains relatively constant with depth. The other cores show a much lower variation because the extractable arsenic somewhat follows the total. Pore water makes up less than 1 % of the total arsenic and only 0.04 % in the Blackfoot sediment.

Manganese generally resides in higher relative percentages extractable forms (Table 4.14). Mean values of percent manganese in acetic acid extracts range from 24.97 % to 65.23 % and many samples contain nearly 100 % extractable manganese (Figures G143 to G148). Core 2 contained the highest percentage of extractable manganese, and core 1 the lowest. In general, levels of extractable manganese follow the total manganese. The highest relative percents of extractable manganese are in the northern and southern slough areas, cores 3 and 6. Manganese in pore water makes up from 0.87 %

Table 4.14. Percent arsenic held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
1	96.16 (3.75) (89.08-98.61)	3.81 (3.76) (1.39-10.90)	0.04 (0.008) (0.03-0.05)
2	76.95 (10.21) (54.97-87.94)	22.64 (10.04) (11.72-44.72)	0.41 (0.439) (0.01-1.16)
3	83.71 (13.23) (61.5-97.92)	15.38 (12.21) (2.06-36.08)	0.60 (1.26) (0.01-4.23)
4	72.44 (10.49) (51.46-89.45)	27.17 (10.48) (10.40-48.44)	0.38 (0.48) (0.06-1.79)
5	86.22 (6.26) (75.6-95.22)	13.40 (6.40) (4.42-24.35)	0.38 (0.34) (0.03-1.21)
6	77.07 (11.92) (53.81-91.92)	21.43 (11.38) (7.72-45.66)	1.50 (2.05) (0.02-7.41)

Table 4.14 continued. Percent manganese held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
1	75.03 (9.74) (55.93-81.75)	24.97 (9.74) (18.25-44.07)	0.00 (0.00)
2	33.68 (23.28) (0.00-63.44)	65.23 (23.85) (34.72-99.72)	1.10 (0.70) (0.25-2.03)
3	44.88 (17.38) (0.00-63.62)	53.89 (17.36) (35.55-98.53)	0.87 (0.57) (0.25-2.03)
4	48.22 (10.03) (31.84-62.69)	49.90 (10.03) (36.19-66.59)	1.88 (2.22) (0.13-8.56)
5	67.71 (13.57) (43.84-94.16)	30.18 (13.04) (3.42-53.59)	2.10 (2.17) (0.03-8.78)
6	49.37 (15.32) (32.93-71.39)	50.10 (15.34) (28.39-66.47)	0.53 (0.60) (0.04-2.10)

Table 4.14 continued. Percent iron held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
1	97.46 (0.85) (96.28-98.78)	2.55 (0.85) (1.22- 3.72)	0.00 (0.00)
2	83.54 (13.60) (55.38-94.48)	16.38 (13.58) (5.52-44.51)	0.08 (0.075) (0.00-0.21)
3	78.40 (23.60) (0.00-94.34)	22.05 (23.30) (7.71-99.87)	0.18 (0.19) (0.01-0.76)
4	85.56 (7.80) (65.81-96.15)	14.09 (8.05) (1.37-33.83)	0.34 (0.68) (0.03-2.48)
5	89.18 (4.22) (78.15-96.99)	10.32 (4.10) (2.99-21.37)	0.49 (0.84) (0.0-3.33)
6	80.64 (13.33) (55.13-97.23)	19.17 (13.34) (2.69-44.66)	0.19 (0.14) (0.03-0.51)

Table 4.14 continued. Percent copper held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
1	82.41 (2.49) (80.20-86.67)	17.59 (2.49) (13.33-19.8)	0.000 (0.000)
2	42.89 (22.70) (8.13-85.24)	59.99 (21.72) (14.76-91.81)	0.29 (0.350) (0.0-1.09)
3	66.68 (19.12) (37.19-84.37)	33.32 (19.12) (15.63-62.81)	0.005 (0.009) (0.0-0.03)
4	58.82 (11.37) (34.55-75.38)	41.13 (11.36) (24.62-65.45)	0.045 (0.120) (0.0-0.43)
5	50.20 (27.95) (0.00-96.73)	49.58 (27.78) (3.21-99.94)	0.240 (0.440) (0.0-1.79)
6	73.29 (16.99) (41.01-96.33)	26.67 (17.01) (3.57-58.97)	0.020 (0.030) (0.0-0.10)

Table 4.14 continued. Percent zinc held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)	Mean % in pore water (Std. Dev.) (Range)
1	79.78 (12.89) (55.00-89.29)	20.22 (12.89) (10.71-45.00)	0.00 (0.00)
2	33.76 (12.78) (16.36-51.71)	65.94 (12.73) (48.06-83.12)	0.30 (0.20) (0.06-0.60)
3	62.11 (27.64) (0.00-92.10)	37.80 (27.61) (7.89-99.71)	0.09 (0.12) (0.01-0.38)
4	40.10 (16.49) (15.90-62.23)	59.19 (16.69) (37.63-83.88)	0.70 (1.61) (0.02-5.75)
5	65.48 (19.74) (23.98-88.99)	34.04 (19.79) (10.83-74.88)	0.48 (0.56) (0.04-1.91)
6	54.78 (24.86) (24.50-96.13)	45.16 (24.89) (3.84-75.49)	0.07 (0.06) (0.01-0.21)

Table 4.14 continued. Percent lead held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)
1	7.83 (10.20) (0.00-25.00)	92.17 (10.20) (75.00-100.00)
2	53.11 (9.99) (39.84-69.57)	46.89 (9.99) (30.43- 60.16)
3	54.60 (8.14) (39.81-70.60)	45.45 (8.25) (29.40- 60.91)
4	46.59 (9.87) (34.23-68.57)	53.41 (9.87) (31.43- 65.77)
5	55.03 (9.14) (41.47-76.04)	44.97 (9.14) (23.96- 58.53)
6	60.55 (12.90) (34.95-79.34)	39.18 (12.83) (20.66- 65.05)

Pore water was not analyzed because sample volumes were insufficient.

Table 4.14 continued. Percent cadmium held in different fractions of cores.

Core #	Mean % in resistant fraction (Std. Dev.) (Range)	Mean % in acetic acid extract (Std. Dev.) (Range)
1	6.88 (9.10) (0.00-23.08)	93.12 (9.10) (76.92-100.00)
2	19.78 (19.41) (0.00-50.00)	80.22 (19.41) (50.00-100.00)
3	47.98 (32.18) (0.00-89.47)	52.02 (32.18) (10.53-100.00)
4	29.40 (18.42) (0.00-63.64)	70.60 (18.42) (36.36-100.00)
5	44.72 (21.02) (3.70-73.33)	55.28 (21.02) (26.67- 96.30)
6	48.89 (23.48) (15.38-82.26)	51.11 (23.48) (17.74- 84.62)

Pore water was not analyzed because sample volumes were insufficient.

to 2.10 % of the total, except in core 1 where it is essentially undetectable.

Blackfoot sediment contains only an average of 2.55 % extractable iron (Table 4.14) whereas Clark Fork sediment means range from 10.3 % to 22.1 % (Figures G149 to G154). Cores 3 and 6 contain the highest percentages of extractable iron and also show the highest variability. Pore water iron is, on the average, less than 0.5 % of the total iron, but values do range up to 3.33 %.

Mean extractable copper ranges from a low of 17.59 % in core 1, to 59.99 % in core 2. The range is quite variable reaching 91.8 % in core 2. There appears to be less extractable copper in core samples that have higher total copper (Figures G155 to G160). This trend is especially apparent in cores 3 and 6. Pore water contains only an infitesimal amount of the total, reaching above 0.5 % in only one sample.

Extractable zinc shows a very large variability in relative percent of total (Table 4.14, Figures G161 to 166). Core 3 has values that range from 7.9 % to 99.7 %. Such extreme ranges are common in all the Clark Fork cores. The Blackfoot core has a lower mean relative percent of extractable zinc and lower total concentrations. In general percent of zinc in the pore water is quite low, mean values below 0.7 %, but some samples contain up to nearly 6 % of the zinc in the pore water (core 4).

The relative percent of extractable lead is extremely variable. and generally quite high. Core 1, in the Blackfoot, contains a mean of 92 % extractable lead with samples up to 100 %. The Clark Fork cores contain lower means, 39.2 5 to 53.4 %, and fairly narrow ranges (Table 4.14, Figures G167 to G172). In general, Clark Fork cores, which have much higher total concentrations, contain about one-half extractable lead. The Blackfoot

core, which has low total lead, contains 90 % extractable lead.

Cadmium in the extractable fraction of the core samples shows tremendous variation, ranging from a low of 10.5 % to 100 % (Table 4.14). Mean values show somewhat lower values in Clark Fork samples than in the Blackfoot core (Figures G173 to G178, Table 4.14). The very low total concentrations in core 1 are composed almost completely of extractable cadmium, whereas the Clark Fork cores average from 51.1 % to 80.2 %. There are no obvious trends in the absolute versus relative data.

For most metals the Clark Fork samples contain a higher proportion of extractable fraction. But for lead and cadmium the opposite trend is present. For most metals and cores, the concentration increases below the surface. Sometimes this increase is over ten times the surface values, representing a major difference in metal content at depth.

TOTAL ORGANIC CARBON IN CORES AND GRAB SAMPLES

Grab samples from the Blackfoot contain an average of 1.65 % total organic carbon and range from 0.20 to 3.73 % (Figure G179, Table 4.2). Clark Fork sediment contains slightly higher values ranging from 0.93 to 4.52 % and averaging 2.40 %.

The range of mean organic carbon in the cores is very similar to that in the grab samples, ranging from 1.04 to 2.34 % (Table 4.14a). All the cores are suprisingly similar, with individual samples ranging from a few tenths of a percent to a few percent (Figures G180 to G185). All the Clark Fork cores have the high organic carbon contents at or near the surface, which then decrease somewhat downwards. But some cores show an increase at deeper levels as well (core 6).

Table 4.14a. % Organic Carbon in Cores.

Core #	Mean	Std. Dev.	Minimum	Maximum	n
1	2.34	1.39	1.58	5.17	6
2	1.21	1.31	0.10	3.40	9
3	1.65	0.74	0.84	3.62	15
4	1.26	1.03	0.18	3.25	13
5	1.04	0.49	0.35	2.19	15
6	2.14	1.18	0.70	4.32	11

DISCUSSION

COMPARISON TO OTHER SEDIMENT SYSTEMS

The above sections have set the stage for a discussion of the Milltown Reservoir sediments in the context of other natural and man-made systems. We will make this comparison metal by metal, to examine the magnitude of the problem at Milltown. In all metal analysis of sediment it is best to establish the background levels, so that an "enrichment factor" can be calculated. In the Milltwon area we have a built in background system, the Blackfoot River. The Clark Fork river has received excess heavy metals since the beginning of mining in the Butte area, and throughout the drainage, in the 1860's. The load of metals was increased tremendously when the Anaconda smelter initiated milling in 1883 (Weisel, 1972). Before the construction of the settling ponds at Warm Springs, the sediment from the milling operations adversely affected the Clark Fork well past Missoula (Casne and Botz, 1975). Water quality increased dramatically with the construction of the ponds, but severe contamination of the sediments in the drainage is well established, and has resulted in the designation of two U.S.E.P.A. Superfund sites, one at Silver Bow Creek and one at Milltown.

The Blackfoot River has undergone much less impact from mining and milling. There are no major industries or impoundments in the entire Blackfoot drainage, until the confluence with the Clark Fork at Milltown, where the Champion mill is located. Mining in the upper reaches of the Blackfoot in the late 1800's and early 1900's has caused some local water quality problems (Spence, 1975; Casne and Botz, 1975), but in general, the drainage is relaivety unaffected by the small scale mining operations.

So, from the standpoint of sediment analysis of Milltown reservoir, the sediments originating in the Blackfoot should represent a fairly reasonable background from which to judge the amount of enrichment from the Clark Fork

river. As well, there is a considerable amount of data on the metal concentrations of lake and river sediment from throughout the world. By examining this data we can establish a reasonable baseline for each of the metals analyzed in the Milltown sediment. Table 4.15 lists some of the accepted background values for metals in sediment compared to Blackfoot sediment collected in this study.

TABLE 4.15

Background concentrations of metals in various sediments. All values ppm of total metals in sediment. The two values for the Blackfoot River sediment represent grab samples/cores.

Metal	Lake Michigan	Wisconsin Lakes	Lake Washington	Recent Lake Sed.	Fossil Lake Sed.	Shale Standard	Blackfoot
As	11	2	10	---	---	13	15/6.4
Mn	---	---	---	760	406	850	281/255
Cu	44	22	16	45	25	45	33/36
Zn	120	15	60	118	105	95	128/52
Pb	40	2	20	30	34	20	14/19
Cd	---	2.5	---	0.4	0.2	0.3	0.7/1.0

This data indicates that the Blackfoot sediment falls within or near the expected range of metal content of un-contaminated, "pristine", sediment systems. The Clark Fork sediment is entirely different, having much higher than background levels of total metals. From inspection of the published and Blackfoot data we have chosen levels of concentration for each metal to represent background (Table 4.16).

TABLE 4.16

Background levels for metals analyzed in this study.

Metal	Background (ppm)
As	10
Mn	250
Cu	35
Zn	60
Pb	25
Cd	0.4

Iron is not considered in this analysis because it is quite variable in natural systems, ranging from 17,000 to over 50,000 ppm. The Milltown sediment averages about 23,000 ppm, well within the range in sediments of all types.

With these background levels, we can determine the relative enrichment factor of various metals in Milltown Reservoir. We have calculated two factors based on the mean concentrations found in the surface sediments (grab samples) and that in the cores in the Clark Fork arm of the reservoir. Because some of the sampling sites located in the Clark Fork arm of the reservoir are influenced by the Blackfoot sediment, enrichment factors are conservative (Table 4.17).

TABLE 4.17

Enrichment factors for sediments in Milltown Reservoir.

Metal	Enrichment Factor for core data	Enrichment Factor for grab data
As	32.0	5.8
Mn	6.6	5.2
Cu	62.3	12.8
Zn	67.4	29.5
Pb	10.5	2.7
Cd	37.3	15.8

The enrcihment factors for the core data show that the sediment below the surface has a larger amount of contamination, and that generally, the Milltown sediments contain many times the background levels expected in such a system. Because the core data represent a thicker sequence of sediment they problably more precisely characterize the contamination. These factors represent very significant enrichment when compared to other known areas of contamination.

Lake Washington, in the Seattle-Tacoma area of Washington, is well studied because of arsenic and other heavy metal contamination by a copper smelter in Tacoma. The Lake Washington sediments were enriched in arsenic by a factor of 20 over the background levels. Arsenic in the Milltown sediments is enriched by a factor of 32 in the core samples and 5.8 in the surface sediment. Other contaminated lake systems have much lower enrichment factors. Lake Erie, well known for various metal contamination problems, is enriched in arsenic by a factor 5.5. So, by several comparisons, Milltown Reservoir is considerably enriched in arsenic. A similar situation exists for the other metals.

The enrichment factors of 62.3 and 12.8 for copper in the subsurface and surface sediment respectively, are considerably greater than the factor of 3 seen in Lake Washington and the 4 fold enrichment in Lake Erie. Some Wisconsin lakes show copper enrichment by a factor of 12, which is still considerably less than the Milltown sediments. Zinc concentration is even more dramatic. Lake Michigan contains 2.5 times the background levels of zinc, Lake Washington 4 times, and Lake Erie 6 times. None of these lakes approaches the 29.5 to 67.4 enrichment factors found for zinc in the Milltown sediment.

Lead in Milltown is more in line with typically polluted lake systems in this country. Lake Washington is enriched in lead by a factor of 20, considerably more than the maximum of 10.5 for the Milltown sediment. However, the Wisconsin lakes mentioned above, have 9 times the background level of lead and Lake Michigan is enriched 3.5 fold. So, Milltown compares well with those systems. Cadmium shows very high levels of enrichment eventhough the absolute values are low. Cadmium is in very short supply in natural systems, so that small absolute concentrations lead to relatively high enrichment factors.

The next question might be, "How do the absolute metal contents in the Milltown sediments compare to other systems?", Table 4.18 makes some comparisons.

TABLE 4.18

Total metal concentrations (in ppm) of some lake sediments
known to be enriched over the background levels.
Milltown sediments reported in mean grab sample/core values.

Metal	A	B	C	D	E	F	G	H	I	Milltown
As	22	51	200	3.2	-	21	-	-	-	58/320
Mn	-	-	-	-	-	407	-	590	4554	1290/1648
Cu	75	268	50	59	-	269	302	49	-	449/2182
Zn	317	92	230	42	500	631	-	250	2256	1767/4045
Pb	145	124	400	-	650	361	136	150	2580	68/262
Cd	-	4.6	-	2.4	-	6.4	21.	17.6	6.3/14.9	

*Data from Forstner and Wittman (1981), Crecelius (1975), Coggins, et al., (1979), Henriksen and Wright (1978), and Reece, et al. (1978).

A:Lake Michigan, B:Wisconsin Lakes, C:Lake Washington, D:Lake Erie, E:Danube, Neckar and Ems rivers, F:Garroch Head sewage disposal area, England, G:Hyperion sewage outfall area, Los Angeles, California, H:Small Australian reservoirs in mining district, I:Coeur d'Alene River sediment heavily contaminated by milling and mining, Idaho.

**Data from A through D represent maximum values; other data is averaged.

Looking at arsenic we see that the average content in Milltown sediments is higher than most other systems. This enrichment is even greater than table 4.18 demonstrates because the values reported for sediment other than Milltown, are mostly maximum values. Milltown sediment contains up to 1590 ppm total arsenic, compared to a high of 200 ppm in Lake Washington, the highest reported in Table 4.18. Total manganese and zinc is in much greater concentrations than other sediments, except those found in the highly polluted sediment of the Coeur d'Alene River. Mean total zinc values in the Milltown sediment are several times greater than those seen in Lake Michigan and Lake Washington. Manganese is much greater than most other sediments, except those contaminated in the Coeur d'Alene drainage.

Copper shows an extraodinary concentration. High values for total copper in sediments is on the order of 270 ppm. Even in the sediment accumulating around the sewage outfall at Hyperiaon in southern California, total copper values reach only 302 ppm. The surface sediments in Milltown have a total mean copper concentration of 449 ppm, and the mean value for the cores is 2,182 ppm, several times greater than sediment contaminated by sewage sludge.

Lead values are somewhat analogous to those seen in sediments from several enriched areas (Table 4.18) and do not approximate the severly polluted Idaho sediments. Cadmium is another situation entirely. Cadmium forms such a small proportion of natural sediment that relatively small concentrations, compared to say arsenic or zinc, may represent considerable enrichment (see above). Typically areas where there is well documented metal contamination contain a few ppm cadmium. The hyperion sewage outfall sediment contains 21.3 ppm cadmium, a very high value. And even the Coeur d'Alene sediments contain only 17.6 ppm cadmium. Milltown core samples contain a mean of 14.9 ppm total cadmium and up to 53 ppm. Such values are extremely high.

Milltown reservoir sediments contain very large concentrations of heavy

metals that are extremely enriched above background levels and rival many contaminated sediment systems. Several metals have concentrations that are only found in areas of sewage sludge outfall or other extreme cases of contamination. This is somewhat disturbing considering that the largest and most likely source, the Anaconda area, is nearly 100 miles upstream from the contaminated sediment at Milltown. The fact that most of metal concentrations are lower in the upper levels of the reservoir suggests that the transport of metals into the reservoir was much greater in the past. But because of metal mobility within the sediment the precise change is very difficult to determine. The problem that remains now is the huge amount of metals that are available to the natural surface and ground water systems. These absolute values of metals are quite large.

ABSOLUTE AMOUNTS OF METALS IN RESERVOIR SEDIMENT

Milltown reservoir contains approximately 3.4 million cubic meters of seidment (see Sedimentation and Stratigraphy section). Assuming a typical density of sediment of 1.8 g/cc, there are 6.1 x 10^{12} grams (6.5 million tons) of sediment in the reservoir. By using the average concentrations of various metals we can determine the total amount of metals residing in the reservoir. The various amounts residing in different fractions can then be calculated to establish the actual amounts of metals available in different forms (conceptual forms). Let us start this discussion of absolute metals amounts with the total metal contents.

By using the mean concentrations of arsenic in the grab samples, we see there is approximately 354 million grams (390 tons) of arsenic in the reservoir sediment (Table 4.19). The mean values for the core samples produce total arsenic amounts of 1,615 million grams (1,779 tons). Assuming a

TABLE 4.19

Total amounts of metals in sediments of the Clark Fork arm of
Milltown Reservoir.

ESTIMATES FROM GRAB SAMPLE DATA

amounts in millions of grams and (tons)

Metal	Mean Conc Total	Amt in Total	Backgrd Conc	Amt Expect	Excess	Amt in AA Ext	Amt in Pore W
As	58 ppm	353.8 (389.6)	10 ppm	61 (67.2)	292.8 (322)	107.5 (118)	0.35 (0.39)
Mn	1290 ppm	7,900 (8700)	250 ppm	1,500 (1680)	6,400 (8020)	5,000 (5507)	62 (976.6)
Cu	449 ppm	2,740 (3018)	35 ppm	210 (232)	2,530 (2786)	1,400 (1546)	0.08 (0.09)
Zn	1767 ppm	10,800 (11,900)	60 ppm	370 (407)	10,400 (11,493)	7,600 (8390)	0.97 (1.07)
Pb	68 ppm	420 (463)	25 ppm	153 (168)	267 (295)	159 (175)	0.013 (0.014)
Cd	6.3 ppm	38 (42.3)	0.4 ppm	2.4 (2.7)	35.6 (39.6)		
ESTIMATES FROM CORE SAMPLE DATA							
As	320 ppm	1,615 (1779)	10 ppm	61 (67.2)	1,554 (1712)	286 (314)	4.4 (4.8)
Mn	1648 ppm	10,100 (11,123)	250 ppm	1,500 (1680)	8,600 (9394)	5,000 (5506)	130 (144)
Cu	2182 ppm	13,300 (14,659)	35 ppm	210 (227)	13,100 (14,427)	5,600 (6177)	16 (17.6)
Zn	4045 ppm	24,700 (27,251)	60 ppm	370 (407)	24,330 (26,844)	12,000 (13,189)	81.5 (90)
Pb	262 ppm	1,600 (1784)	25 ppm	153 (168)	1,447 (1616)	740 (821)	
Cd	14.9 ppm	89.7 (99.8)	0.4 ppm	35.6 (39.6)	54.1 (60.2)		

background concentration of 10 ppm we would expect to find 61 million grams (67.2 tons) of arsenic in the sediment trapped behind the dam. This leaves an excess of 292.8 million grams (322 tons) of arsenic using the grab sample values or 1,554 million grams (1,712 tons) of arsenic using the core value. Again, because the core data better represents the vertical distribution of metals, Milltown Reservoir contains approximately 1,800 tons of arsenic, 1,700 tons of which is in excess over that expected in normal sediments.

Within that amount of arsenic it is important to know the portion that is directly available to the ground water system and that which may be available under specific chemical situations. Using the percentages of arsenic in the pore water of the grab samples we calculate that 0.35 million grams (0.39 tons, or 779 lbs) of arsenic reside in the pore water of the surface sediment. Using the core pore water percentages 4.35 million grams (4.79 tons) are available. This arsenic is already in solution within the sediment and is easily moved into the ground water, surface water or the biota. Tied up in easily extractable compounds (oxides of iron and manganese, carbonates, etc.), the acetic acid extractable arsenic represents a hugh store of potentially dangerous metal. Grab samples contain an average of 30.4 % extractable arsenic, and core samples 20 %. The calculated amount of arsenic residing in the extractable phases is 108 million grams (118 tons) for the grab sample data and 286 million grams (314 tons) for the core data (Table 4.19). Under reducing conditions, which commonly prevail throughout the reservoir, this arsenic can be leached from the sediment and become available to the surface and ground water system. Under the metabolic action of plants and bacteria this may represent a large potential source of arsenic to the biotic system.

Other metals have even greater amounts stored in the reservoir sediment. Approximately 7,900 million grams (9,700 tons) of manganese resides in the

surface sediment (grab sample data). By using the core data we estimate that 10,100 million grams (11,074 tons) of manganese are present. These values represent excesses of 6,400 million grams (8,020 tons) and 8,600 million grams (9,394 tons) respectively (Table 4.19). Pore water in the grab samples contain 62 million grams (76.6 tons) of manganese and core pore water contain 130 million grams (144 tons) of manganese. 5,000 million grams (5,507 tons) of manganese are available in the extractable phases of the sediment (grab sample and core data).

Copper shows large excesses when compared to background data. An excess of 2,530 million grams (2,786 tons) of the 2,740 million grams (3,018 tons) total copper is calculated using the grab sample data. Core data gives a total copper content of 13,300 million grams (14,659 tons), of which 13,100 million grams (14,427 tons) is excess. Because the background amounts are so small compared to the total copper present, essentially all the copper is excess. Only 80 thousand grams of copper resides in the pore water of the surface sediment (grab sample data) but using the mean core concentrations reveals that 17.6 tons of copper is available. Extractable copper calculated from the grab sample data is 1,400 million grams (1,546 tons), and 5,600 million grams (6,177 tons) using the core data.

The amount of zinc in the sediment is also fairly significant. We estimate 10,800 million grams (11,900 tons), from the grab sample data, and 24,700 million grams (27,251 tons), from the core data, of zinc reside in the reservoir. As for copper, essentially all of this is excess, 10,400 million grams (11,493 tons) and 24,300 million grams (26,844 tons), respectively. Of the total, 7,600 million grams (8,390 tons) and 12,000 million grams (13,189 tons) are calculated to lie in extractable phases (grab and core data, respectively). As well, grab sample pore water contains approximately 1

million grams (1.07 tons), and core pore water 881.5 million grams (90 tons) of zinc.

Lead shows considerably smaller amounts of excess than zinc, more akin to arsenic. Lead is in excess by from 267 million grams (295 tons) to 1,450 million grams (1,616 tons), respectively for grab sample and core data. Cadmium is in the lowest amounts totalling 38 million grams (42.3 tons) using the grab sample data, and 90 million grams (100 tons) using the mean core values.

From table 4.19 it is apparent that a large amount of metals reside in Milltown Reservoir. Tens of thousands of tons of arsenic, manganese, copper, zinc and lead are trapped behind the dam. Of this amount, hundreds to thousands of tons of metals are directly available to the system in the pore water, and many tens of thousand more in the extractable phases within the sediment. It is important to note that most of these metals are not expected, and that the excess commonly approaches the values of total metals. By the nature of these calculations, they probably represent fairly conservative estimates of the metals in the reservoir sediment. For example, at one locality (site 30, core 6) zinc reached a maximum of 11,200 ppm. If such concentrations are common in sediments we did not sample, or extend fairly far from the sampling sites we chose, the average could be considerably greater, and hence the tonage much larger. As well, the sediments deeper in the reservoir (below are sampling depths) could easily contain higher concentrations of metals. Because the reservoir has been filled since 1908, and the early operations in the Anaconda-Butte area produced copius amounts of metals dumped directly into the drainage, we would expect the deepest sediments to contain more metals, and therefore, the estimates in Table 4.19 are probably somewhat low.

METAL TO METAL CORRELATIONS

Trace metals in sediment is commonly associated with clays, iron and manganese oxides/hydroxides and organic compounds. These associations are seen in strong positive correlations between heavy metals and grain size, iron and manganese and organic carbon content, respectively. The Milltown grab sample data shows no strong correlations between metals and percent clay and silt, or organic carbon. The cores show similar trends, where there is little or no control by grain size or organic content, eventhough those parameters vary tremendously within a core (see Sedimentation and Stratigraphy section). However, the total grab sample data does show very strong correlations between various metals (Table 4.20).

Arsenic, copper, zinc, lead, cadmium and manganese are all strongly correlated with one another. These correlations suggest all these metals reside in associated compounds in the sediment. In the acetic acid extractions (Table 4.21), correlations between the same metals are lower. But, some of the metals are strongly correlated with iron. These associations very likely result from the types of minerals and compounds holding the metals. Arsenic, copper, zinc, lead and cadmium are commonly associated with one another in sulfide minerals. Such minerals are quite common in the mineralized areas in the upper drainage. The ore at Butte contains many sulfides composed of these metals (Table 4.22). One interesting aspect of the Butte ores is the zonation of the ore body. The central zone contains abundant Enargite (arsenic-copper sulfide, Table 4.22). There is very strong correlations between copper and arsenic in the total metals in the grab samples, and in cores that contain relatively high values of arsenic and copper (Table 4.23). This data, combined with the correlations between metals commonly found in sulfides, strongly suggests that the enriched metals may

Spearman Rank-Order Correlation Coefficient

GRAB SAMPLES - Totals

	ug/ml											
	As	Mn	Fe	Cu	Zn	Pb	Cd	Ni	% Sand	% Silt	% Clay	%Org C
As	1	.79***	.34*	.92***	.83***	.88***	.87***	---	-.22	.17	.44*	.37*
Mn		1	.36*	.84***	.86***	.86***	.88***	---	-.17	.07	.50*	.43
Fe			1	.38*	.43*	.38*	.46*	---	-.66***	.60***	.47*	.23
Cu				1	.90***	.94***	.93***	---	-.26	.20	.53***	.44*
Zn					1	.87***	.94***	---	-.22	.14	.52***	.38*
Pb						1	.93***	---	-.28*	.24	.46*	.43
Cd							1	---	-.34*	.26	.59***	.49**
Ni								1	---	---	---	---

* $p<0.05$
** $p<0.01$
*** $p<0.001$

TABLE 4.20

GRAB SAMPLE - Acetic Acid Extracts

	ug/g										
	As	Mn	Fe	Cu	Zn	Pb	Cd	Ni	% Sand	% Silt	% Clay
As	1	.59***	.29**	.71***	.55***	.61***	.59***	.46***	-.08	.01	.24*
Mn		1	.74***	.86***	.86***	.59***	.87***	.56***	-.23*	.12	.43***
Fe			1	.77***	.83***	.40***	.83***	.52***	-.44***	.34**	.53***
Cu				1	.92***	.64***	.93***	.59***	-.21	.11	.41***
Zn					1	.62***	.94***	.55***	-.25*	.14	.46***
Pb						1	.66***	.58***	-.41***	.35**	.36***
Cd							1	.62***	-.32**	.19*	.53***
Ni								1	-.35**	.27**	.40***

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

TABLE 4.21

Mineral	Chemical Formula	Occurrence and Abundance						
		Pre-Main Stage		Main Stage				Post-Main Stage
		Potassium Silicate Alteration	Veins	Deep Level Cp Zone	Central Zone	Intermediate Zone	Peripheral Zone	Metamorphic
Acanthite (Argentite)	Ag_2S					r	m	
Aikinite	$PbCuBiS_3$			r			r?	
Alabandite	MnS							m
Alunite	$KAl_3(OH)_6(SO_4)_2$				t			
Andorite	$PbAgSb_3S_6$					r	r?	
Anhydrite	$CaSO_4$	m						
Ankerite	$Ca(Fe,Mg)(CO_3)_2$			t	t	t	m	
Apatite	$Ca_5(F,Cl,OH)(PO_4)_3$	t		t	t	t	m	
(Lewistonite)	$(Ca,K,Na)_6(OH)(PO_4)_3$				r?			
Arsenopyrite	$FeAsS$					r		
Barite	$BaSO_4$			t	t	t	t	
?Betekhtinite	$Cu_{10}(Fe,Pb)S_6$ (?)			t	t	t		
Bornite	Cu_5FeS_4			c	t	a		c
Calcite	$CaCO_3$	t		m	t	m	c	
Chabazite	$CaAl_2Si_4O_{12}$ $6H_2O$						r	
Chalcocite	Cu_2S			m	a	c		
Chalcopyrite	$CuFeS_2$	c	m	a	r	c	m	c
Colusite	$Cu_3(As,Sn,V,Fe,Te)S_4$			t	m	t		
Covellite	CuS			r	m	t		
Digenite	Cu_9S_5			r	m	t		
Djurleite	$Cu_{1.96}S$				m?	t?		
Dolomite	$CaMg(CO_3)_2$			m	t	m	c	
Enargite	Cu_3AsS_4			m	a	c		
Ferberite	$FeWO_4$						t	
Fluorite	CaF_2	t		t	t	m	m	
Galena	PbS			t	t	t	c	
Gold	Au				r	r	r	
Greenockite	CdS						r	
Gypsum	$CaSO_4$ $2H_2O$			r		r	t	
Helvite	$Mn_4SSi_3Be_3O_{12}$						r	
Hematite	Fe_2O_3	t					r	c
Heulandite	$CaAl_2Si_7O_{18}$ $6H_2O$						r	
Hinsdalite	$PbAl_3(OH)_6PO_4SO_4$				t			
Huebnerite	$(Fe,Mn)WO_4$			t	t	t	t	
Luzonite	Cu_3AsS_4				t			
Magnetite	Fe_3O_4	t	r					
Manganankerite	$Ca(Fe,Mn)(CO_3)_2$					r	t	
Manganocalcite	$(Mn,Ca)CO_3$					t	m	
Manganosiderite	$(Mn,Fe)CO_3$					r	t	
Marcasite	FeS_2						r	
Molybdenite	MoS_2	t	m					
Orthoclase	$KAlSi_3O_8$	c	m					
Pearceite	$(Ag,Cu)_{16}As_2S_{11}$						t	
Polybasite	$(Ag,Cu)_{16}Sb_2S_{11}$						r	
Proustite	Ag_3AsS_3						t	
Pyrargyrite	Ag_3SbS_3						r	
Pyrite	FeS_2	m	m	+	+	+	c	
Quartz	SiO_2	+	+	+	+	+	+	a
(Chalcedony)							m	
Rhodochrosite	$MnCO_3$			t	t	t	a	
Rhodonite	$(Mn,Fe,Ca)SiO_3$						c	
Rutile	TiO_2	t						
Scheelite ±Powellite	$Ca(W,Mo)O_4$	t		t	t	t	t	
Seligmannite	$PbCuAsS_3$						r?	
Siderite	$FeCO_3$					r	t	
Silver	Ag			r	t	t	t	c
Sphalerite	ZnS				t	t	a	
Stephanite	Ag_5SbS_4						r	
Stilbite	$CaAl_2Si_7O_{18}$ $7H_2O$						r	
Stromeyerite	$CuAgS$			r	t?	t	t	
Tennantite	$Cu_{12}As_4S_{13}$			c	t	m	t	m
Tetrahedrite	$Cu_{12}Sb_4S_{13}$						r	
Uraninite	UO_2			r?	r?	r?	r	
Wavellite	$Al_3(OH)_3(PO_4)_2 \cdot 5H_2O$				r			
Wittichenite	Cu_3BiS_3			t	t	t		
Wolframite	$MnWO_4$						t	
Wurtzite	ZnS				r?	r	r	

Symbols Used

+ = very abundant
a = abundant
c = common
m = minor
t = trace amounts
r = rare, one or a few occurrences only

A question mark preceding a mineral questions its identity; a question mark following an abundance symbol questions the amount.

TABLE 4.22

From: Meyer, et al., 1968, p.1382

TABLE 4.23

Spearman Rank-Order Correlation Coefficients - Totals

	Core Number					
Variable Pair	2	3	4	5	6	1
Cu-As		**		**	*	
Pb-As		**	**	**		
Fe-Mn	*			**		
Zn-Mn	*		*	**		
Cd-Mn	*			*		
Silt-Mn	*					
Clay-Mn	*			**		
Zn-Fe	*		*	**		
Cd-Fe	*		*	*	*	
Silt-Fe	**		**			*
Clay-Fe	**		**	*		*
Org C-Fe	**					
Zn-Cu	*					**
Pb-Cu	**	**	*	**	**	**
Cd-Cu	*		*			
Cd-Zn	**	*	**	**	*	
Clay-Zn	*			**		
Cd-Pb	*					
Clay-Cd	*			*		
Org C-Clay	**					
Silt-Cd			*			
Org C-Cu					*	
Org C-Pb					*	
Pb-Zn						*
-Sand-Fe	**		**			**

$* = .80 \leq r < .90$

$** = \geq .90$

reside in the sediments as primary sulfide minerals. THis conjecture is supported by preliminary mineral separations done by John P. Wehrenberg (personal communications) that isolated primary sulfides in the Milltown sediment.

The same metals show somewhat different correlations in the acetic acid extractions. The correlations between arsenic and the other metals decreases drastically in the extractions (Table 4.21). This may result from the fact that many of the metals reside in sulfides, which are recovered during the total dissolutions, but not during the acetic acid extractions. The relatively strong correlations between the metals and manganese and iron in the acetic acid extractions suggests that much of the copper, zinc and cadmium resides in extractable manganese and iron compounds, most likely oxides and hydroxides. This is especially true for particular metals.

Zinc is strongly correlated with iron and manganese in the acetic acid extractions, as well as with copper. Large percentages of the manganese and zinc in the grab samples lie in extractable phases (Table 4.14), so that the correlation between the two is excellent evidence that zinc resides in manganese oxides/hydroxides. The significant and strong correlation with iron suggests that iron oxides/hydroxides are also involved.

In summary, some of the correlations between metals suggest that arsenic, copper, zinc, lead and cadmium may be dominantly tied up in sulfides within the sediment. As well, arsenic, zinc and copper are combined in iron and manganese oxides/hydroxides. If these conjectures are correct then the Milltown sediments contain metals that are unstable in both oxidizing and reducing environments. Under reducing environments, like now exists in the reservoir below a few tens of centimeters, metals will be extracted from the oxides and hydroxides. In the surface sediments, or where oxidizing ground water flows through the sediment, metals from the sulfides will be released.

LOCATION OF A WATER SUPPLY WELL

The location of a water supply well in the Milltown area is fairly straight-forward. The well needs to be placed where it is removed from the sources of contamination. It must have a sustained yield of 100 gpm, including a peak yield of 200 gpm with no adverse effects on existing users. The site must also be located at a site which can be acquired for well construction. One critical assumption for these recommendations is that arrangements for use of the land owned by Champion International can be successfully completed. The two proposed locations are shown in Figure 5.1.

The best location for a water supply well would be along First Street between C2 and 106. The aquifer is thickest in this region, and also has a very high hydraulic conductivity that easily allows for the required yield without impact to existing users. This area is also hydrogeologically isolated from the contaminated flow system. The Blackfoot River is the principal source of recharge to the aquifer. Also, C2 is a proven high-yield well of good quality which has been operated since 1975. However, a routine bateriological sample taken by state officials in June, 1984, showed the presence of fecal coliform. It is believed that well maintenance earlier in the spring may have caused the problem and the well will be disinfected in July, 1984. Five years of monthly bacteriological testing prior to the June sampling never revealed the presence of coliform bacteria. Hopefully, the problem is one which will be remedied by well disinfection. The solution to this problem bears careful scrutiny, for if the aquifer has become contaminated, a site closer to 106 or an alternative site near 109 should be carefully considered.

Residents reported that an old well near the 106 site was damaged by

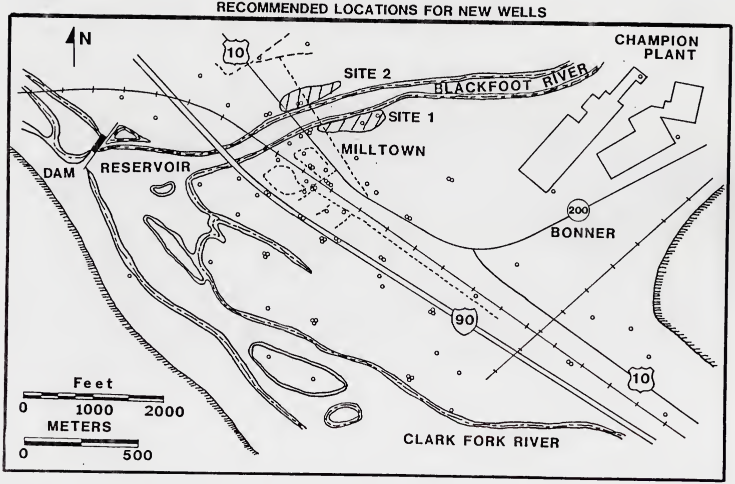

Figure 5.1: Recommended locations for new water supply wells.

highway constuction, apparently the casing was broken, and the well was abandoned. The casing was backfilled with rocks and now may provide an avenue for contaminants to enter the aquifer, were a well located at site 106. A location closer to C2 would be more desirable. The location of a new well adjacent to C2 has the advantage of cross connections, so each could supply backup water when the other needed maintenance. With the solution of the coliform problem a site near C2 is recommended.

An alternative site would be near 109 across Blackfoot River. This site also has a high hydraulic conductivity and is recharged from the Blackfoot River. It is hydrogeological isolated from the contaminated flow system. Construction cost would increase, however, because of the required river crossing.

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GEOPHYSICAL STUDY

INTRODUCTION

The geophysics investigation was intended to exptrapolate well drillers' geologic interpretations by defining the thickness of the unconfined sand and gravel-depth to bedrock at a number of selected locations. The geophysics work was planned to be the first phase of the project effort. The geophysical data would be used to locate bore holes for geological data collection and monitoring well construction. Test holes which could be used to evaluate the hydrologic conditions at potential production well sites also needed to be sited. Both the geophysical survey data and existing geological data were used to plan a monitoring well drilling program. The study was initiated because the-depth-to-bedrock/aquifer thickness was only known at three points and the bedrock structure was anticipated to be complex based on the available geologic maps of the area. The study area is underlain by metasedimentary rocks which have been structurally deformed by the Blackfoot thrust and the Clark Fork Shear Zone.

Three challenging complications were evident at the onset of the geophysical investigation: 1) the short time frame; 2) the need to determine detailed bedrock geology at less than 100 ft below land surface and 3) the presence of boulder zones in the unconfined aquifer. Because the Montana drilling season is short and the project began in July, we expected to begin drilling the monitoring wells within two weeks of project start up. As it eventually turned out, the bidding process for the drilling was slower than anticipated. Therefore, we had several extra weeks within which we could have conducted the geophysical study in a different manner.

The second challenge was provided by the known bedrock structure. The

three pre-existing wells which completely penetrate the aquifer and lie within less than one square mile show that bedrock depth varies from 49 ft to 155 ft. Accordingly, the relief on the rugged bedrock surface was expected to be on the same order of magnitude.

The third complication was an observation by local drillers that zones of boulders "... as big as houses..." comprised parts of the unconfined aquifer. These zones of boulders most likely have a geophysical signature much closer to the bedrock than to the overlying aquifer material.

Based on these challenges, particularly the time and topography constraints, the physical earth properties we chose to measure were density, electrical resistivity and seismic velocity. We also retained Dr. Stephen Sheriff of the Department of Geology at the University of Montana to plan and conduct the study. The following section will present the methodology used to collect the necessary data.

METHODOLOGY

In order to provide the required data described above three geophysical surveys were attempted: 1) a gravity survey; 2) an electrical resistivity survey and 3) a seismic refraction survey. A brief description of each method utilized follows.

GRAVITY SURVEY

It was not cost-effective nor time-effective to complete a gravity survey of the entire study area without an indication of its potential usefulness and accuracy. To test the gravity method, we sited 61 stations in the center of the area (Figure A1). These stations were placed on a rough grid at an average interval of 300 ft. Gravity was measured with a Texas Instruments Inc., "Worden" gravity meter. This instrument can be read to 0.01 mgal. The stations were spaced according to the assumptions that a 0.5 g/cm^3 contrast

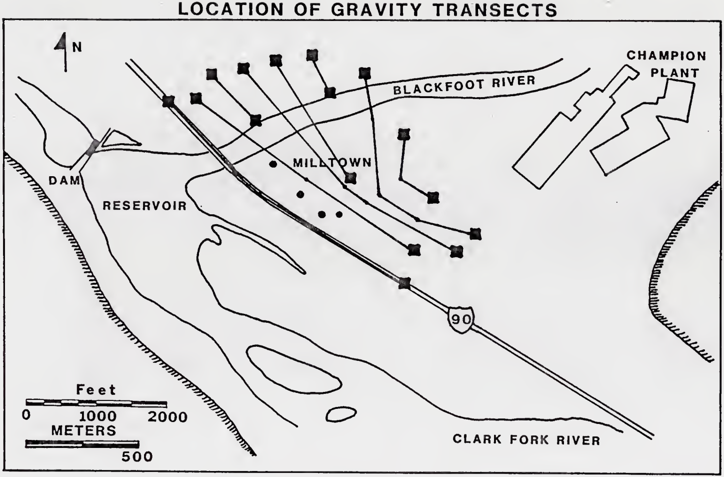

Figure A1: Location of gravity transects.

exists between the alluvium and the bedrock and that a 35 ft step in the bedrock surface can be determined by an anomaly of 0.2 mgal. The station elevations were professionally surveyed to 0.01 ft. A bedrock density of 2.7 g/cm^3 and an alluvium density of 2.1 g/cm^3 were used to evaluate the survey data.

The Bouguer gravity value was calculated for each station using the standard techniques described in Nettleton (1942). These values were contoured by hand to produce a Bouguer gravity map. The gravity data were then correlated with known depths to bedrock using standard linear regression.

ELECTRICAL RESISTIVITY SURVEY

Electrical resistivity was the second geophysical method employed in the Milltown study. Because we were primarily interested in finding a rapid and accurate method to determine the thickness of the alluvium, we employed the Wenner and Schlumberger electrode arrays (Zohdy et al., 1974). A Soiltest R-60 Current Resistivity System was used to collect data. Initially,measurements were taken adjacent to points of known depth to bedrock. A total of five sites were used to evaluate the usefulness of this technique (Figure A2).

Since the electrical properties of the Milltown alluvium are not well known and because of the time constraint, a straight-forward method for plotting and interpreting the data was used. The electrical sounding data were plotted as measured apparent resistivities versus their electrode spacing. These data were interpreted by attempting to match the field data with published "type curves" to determine material layering and thickness (Van Norstrand and Cook, 1966).

SEISMIC REFRACTION SURVEY

The procedure we employed to test the accuracy and usefulness of the seismic refraction method was similar to that for the gravity and electrical

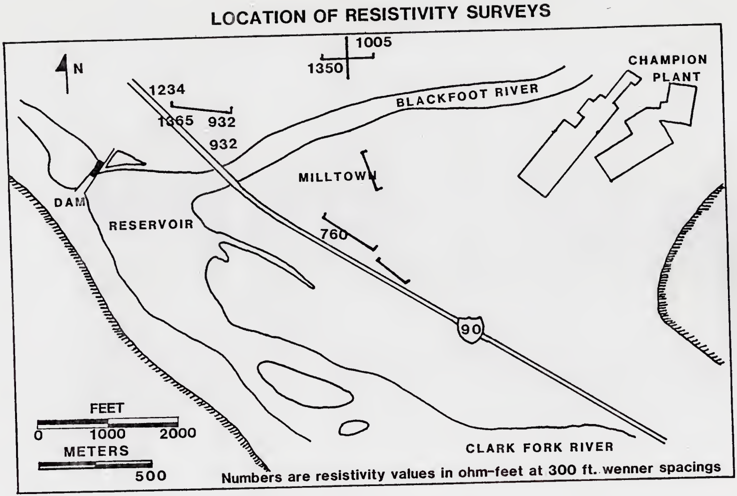

Figure A2: Location of resistivity sites.

resistivity surveys. We performed seismic refraction experiments over several areas where depths to bedrock and/or the water table were known. Data collection was performed using a Nimbus Instruments ES-6 Engineering Seismograph at 17 stations (Figure A3). Different geophone spacings were used for varying situation: within 30 ft of the sledgehammer source, spacings as small as three feet were used; further from the source, the geophone spacing was increased to as much as 30 feet. The sledgehammer was an adequate signal generator for geophones as distant as 130 ft; at greater distances, the signal-to-noise ratio was too small to allow a reasonable determination of the first-arrival times on the seismograms. As a result, a signal was generated by dropping a 350 lb weight 16 ft from a tripod to a steel plate located on the ground. Initially each seismic line was reversed to determine bedrock slope. As more was learned about the bedrock surface, it was not always necessary to reverse the lines to obtain the needed data.

First-arrival times were plotted versus distance from the source and then analyzed to determine seismic velocities and layering depths using standard techniques (Zohdy et al., 1974). The seismic velocities were interpreted to be related to unsaturated alluvium if they fell with in the range of 2,000 to 4,000 ft/s; to be related to saturated alluvium if they ranged from 5,000 to 8,000 ft/s and to be traveling through bedrock at a range of 9,000 to 14,000 ft/s. Interpreted depths to bedrock were obtained from 17 sites. These data were compared to known depths to bedrock by linear regression and correlation.

RESULTS AND DISCUSSION

Of the three geophysical techniques attempted, only seismic refraction correlated well with known values of bedrock depth. The results of each method will be presented and discussed briefly.

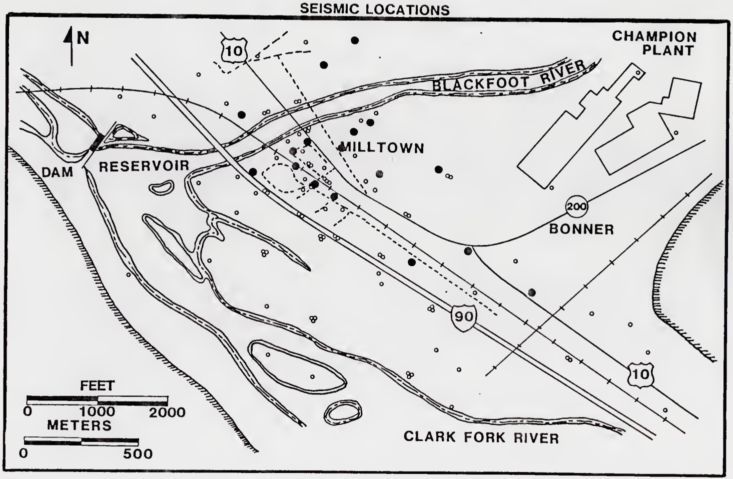
SEISMIC LOCATIONS

Figure A3: Seismic locations.

GRAVITY SURVEY

The results of the gravity survey are presented as a Bouguer gravity map in Figure A4. The more negative Bouguer gravity values represent lower density- thicker alluvium. The Bouguer gravity map is a reliable estimation of the local gravity field; its highs and lows, however, do not correlate with topography, with the survey lines, nor with the time of day that individual stations were occupied. Unfortunately, the values did not correlate well with the three known depths to bedrock. At the completion of the monitoring well drilling project 13 points of known bedrock depth were available for comparison with the gravity data (Figure A5). The Pearson correlation coefficient is 0.47. The gravity map is not a strong function of the bedrock surface.

Apparently, variations in density within the alluvium contribute a signal essentially equal in magnitude to the signal from the deeper interface between bedrock and alluvium. Possibly, the Bouguer low that parallels the Blackfoot River results from the density contrast of thick, recent, unconsolidated sediment with older, more compact alluvium. The gravitational method was not a satisfactory technique for rapidly and economically predicting the thickness of the aquifer in Milltown.

ELECTRICAL RESISTIVITY SURVEY

Resistivity data were collected at five sites and data were matched with "type curves" in an attempt to rapidly determine if the geology at known points coud be deciphered from the survey. Data were fairly consistent, yet we discovered no way to consistently measure the known depth to bedrock with our Schlumberger or Wenner electrical sounding field results. The lack of lateral consistency of resistivity and the lack of independent measurements of the resistivity of the various site materials combined to make the electrical resistivity method unsatisfactory for determining the depth to bedrock in the

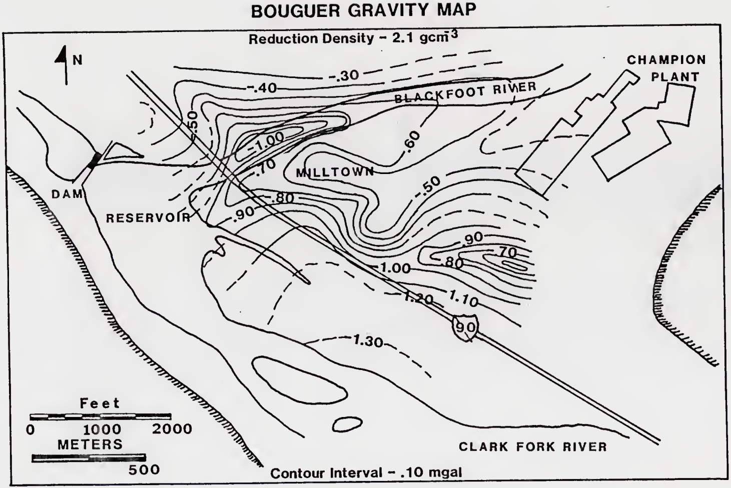

Figure A4: Bouguer gravity map.

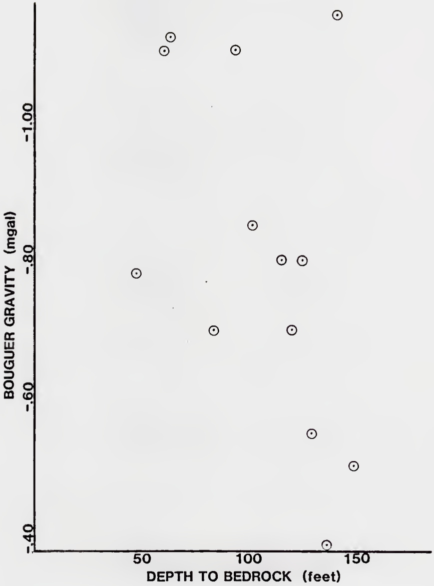

Figure A5: Bouguer gravity vs known bedrock depths.

Milltown area. In fact, predicted values were so variable that we were unable to use the resistivity data to correlate estimates for depth to bedrock with the now-known depth to bedrock as determined from the completed drilling program.

SEISMIC REFRACTION SURVEY

The seismic refraction survey proved to be the best method to determine the depth to bedrock and the thickness of the overlying sand and gravel. Figure A6 presents the interpretation of an example of seismic field data and Figure A7 shows the locations of survey sites and the seismic predicted depth to bedrock. Figure A8 presents an isopach map of the sand and gravel thickness overlying the bedrock based on seismic data. This interpretation shows that the alluvium thickens to the northeast from about 40 ft to over 160 ft. A bedrock high is indicated in the southeast which is covered with about 50 ft of sediment. This interpretation appeared to initially correlate well with known depths to bedrock and minimum depths to bedrock derived form drillers' logs of wells which penetrated alluvium but did not encounter bedrock. The locations of monitoring wells and test wells were selected by using the seismic data and the existing geologic and hydrogeologic information (Woessner and Popoff, 1982).

When the drilling program was completed, the measured depths to bedrock at 13 points were known (Figure A9). An isopach map of sand and gravel thickness based on drilling data is presented in Figure A10. The trend of general aquifer thickening to the northeast and the presence of a bedrock high in the southeastern portion of the area is also evident. Figure A11 presents a plot of the predicted depth to bedrock versus the actual depth to bedrock. The Pearson correlation coefficient is 0.60. The linear regression equation is $d_a = 0.71d_s + 59$ ft, where d_a is the actual depth in feet and d_s is the seismic interpreted depth in feet. This equation can be used to predict

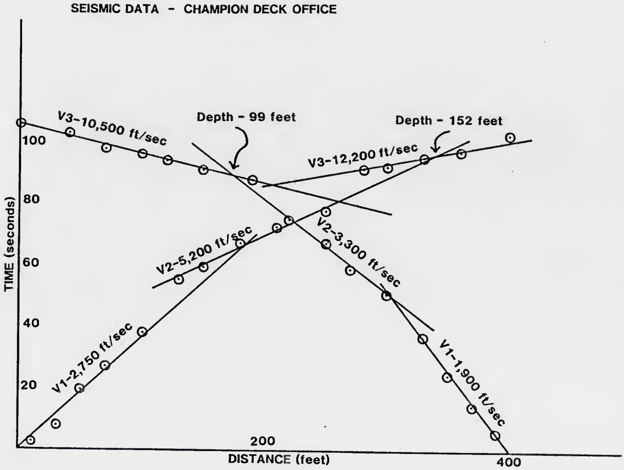

Figure A6: Seismic velocity vs depth.

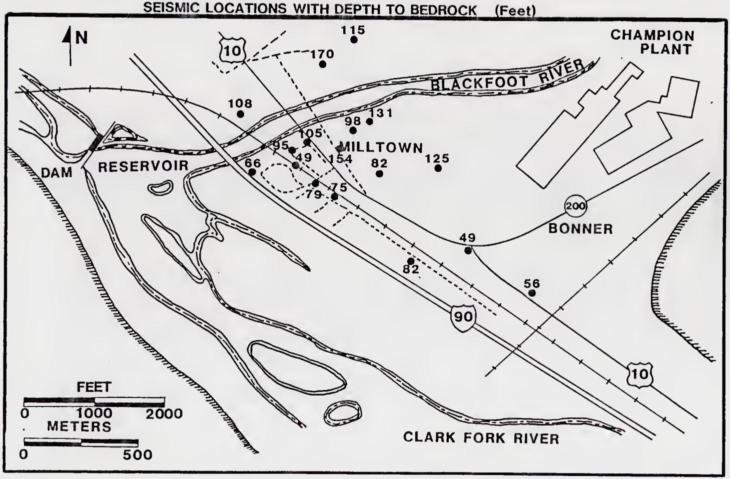

Figure A7: Seismic locations with predicted depth to bedrock.

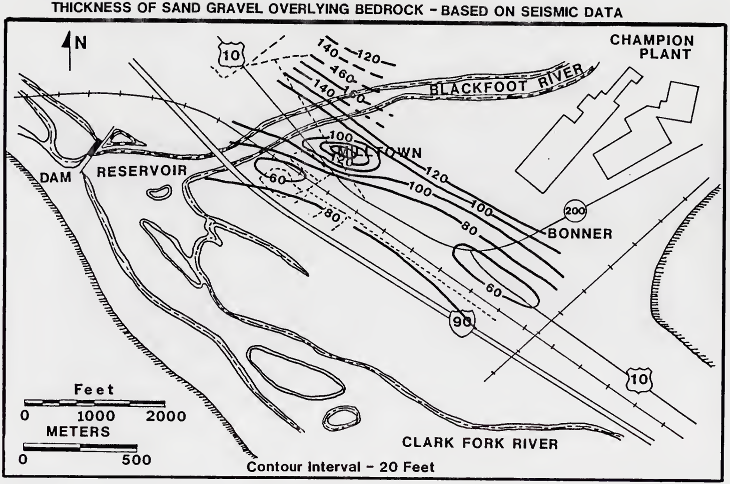

Figure A8: Sand and gravel isopach map based on seismic data.

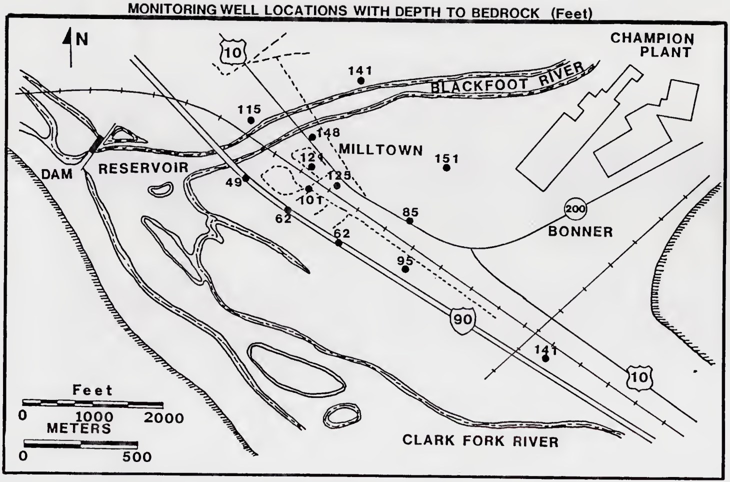

Figure A9: Location of monitoring wells with depth to bedrock.

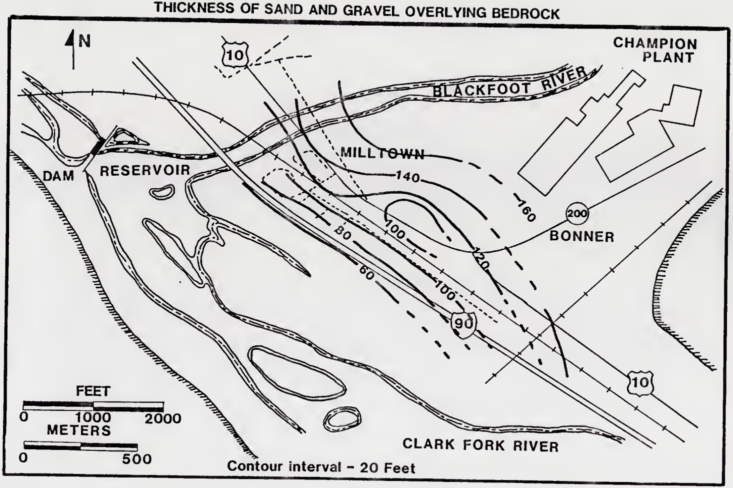

Figure A10: Sand and gravel isopach map.

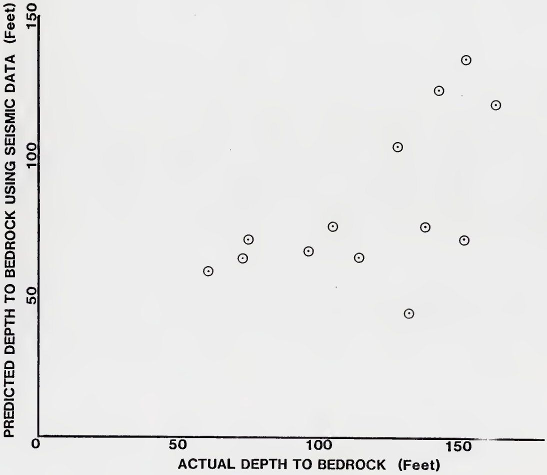

Figure A11: Seismic bedrock depths vs known bedrock depths.

actual depth to bedrock using seismic refraction data in the Milltown area.

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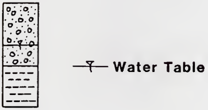
Zohdy, A. A. R., Eaton, G. P. and D. R. Mabey, 1974, Application of surface sufrace grophysics to groundwater invertigations. USGS Tech. of Water Res. Inv., Book 2, Chap. D1, 116p.

APPENDIX B

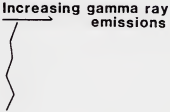
LITHOLOGIC LOGS AND DESCRIPTIONS OF COMPLETED WELL DESIGN

EXPLANATION FOR WELL DESCRIPTIONS

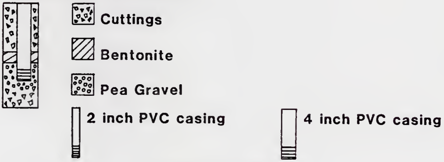
LITHOLOGIC LOG



GAMMA RAY LOG

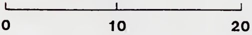


COMPLETED WELL DESIGN

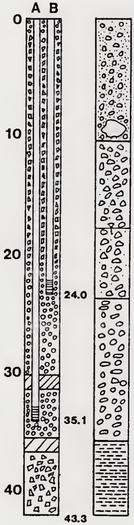


5 feet of screen
Slot Size - .02 inch

SCALE (meters)



WELL 99



0 to 10.7 meters. Sandy gravel. 55 to 70% gravel, 25 to 45% sand, < 1% clay. Subrounded to rounded, poorly sorted, light to medium brown.

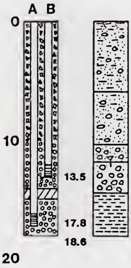
Large boulder between 9.1 and 10.7 meters.

10.7 to 24.4 meters. Gravel. 80 to 90% gravel, 2 to 10% sand, 1 to 5% pebbles, < 2% clay. Subrounded, moderate to well sorted. Colors vary from red to brown to green.

24.4 to 36.9 meters. Pebbly, sandy gravel. 35 to 30% 80% gravel, 10 to 55% pebbles, 2 to 20% sand. Subrounded, moderate to poorly sorted. Colors vary from red to brown to green.

36.9 to 43.3 meters. Argillite. 100% clay. Well sorted, light to medium green. Little to no water.

WELL 100



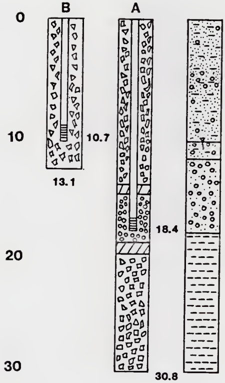
0 to 6.1 meters. Gravelly, pebbly soil. 10 to 20% pebbles, 10 to 20% gravel, 60% sandy soil. Subrounded, poorly sorted, brown.

6.1 to 10.7 meters. Gravelly sand. 50 to 90% sand, 10 to 30% gravel, 5 to 10% pebbles, 0 to 5% silt. Rounded, poorly sorted, brown to black sand and silt; red, brown, green pebbles and gravel.

10.7 to 14.9. Sandy gravel. 70 to 80% gravel, 20 to 30% sand. Rounded, moderately sorted, black sand; brown, red, green gravel.

14.9 to 18.3 meters. Argillite. 100% clay. Well sorted, medium green. Little to no water.

WELL 101



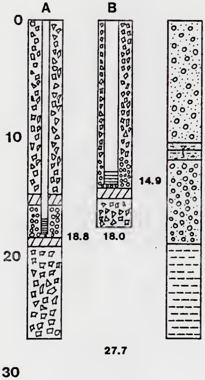
0 to 12.2 meters. Gravelly sand. 30 to 90% sand, 30 to 70% gravel, 20% clay (from 0 to 1.5 m), 20% silt (from 0 to 1.5 m). Rounded, poorly sorted, brown to black sand, clay, and silt; red, brown, green gravel.

4.6 to 6.1 meters. Zone with high gravel content (70%).

12.2 to 18.6 meters. Sandy gravel. 50 to 90% gravel, 10 to 50% sand. Rounded, moderate to poorly sorted, black to brown sand; brown, red, green gravel.

18.6 to 30.8 meters. Argillite. 100% clay. Well sorted, black and geen.

WELL 102



0 to 10.7 meters. Sand and gravel. 50 to 60% gravel, 40 to 50% sand. Rounded to subrounded, poorly sorted, brown sand; red, brown, green gravel.

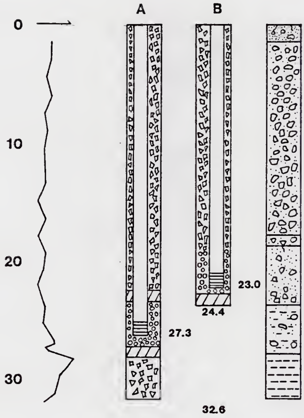
10.7 to 12.2 meters. Clayey, silty sand. 70 to 80% sand, 10 to 20% clay, 10 to 20% silt. Subrounded sand, moderately sorted, black.

12.2 to 19.5. Sandy gravel. 70 to 90% gravel, 5 to 30% sand. Rounded, poorly sorted, black sand; red, brown, green gravel.

16.8 to 18.3 meters. Zone with high sand content (30%).

19.5 to 27.7 meters. Argillite. 100% clay. Well sorted, black to green.

WELL 103



0 to 1.5 meters. Organic rich, gravelly sand. 80% sand, 15% gravel, 5% organics. Subrounded, moderately sorted, light gray to brown.

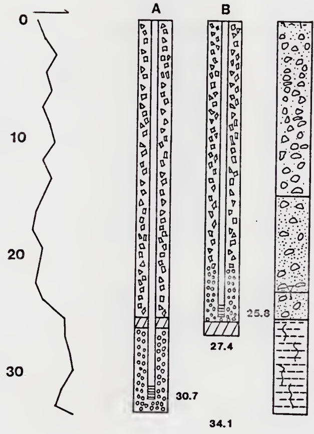
1.5 to 18.3 meters. Sandy gravel. 65 to 85% gravel, 10 to 25% sand, 5 to 10% pebbles. Rounded to subrounded. moderate to poorly sorted. Colors vary from red to brown to green.

18.3 to 24.4 meters. Gravelly sand. 70 to 90% sand, 10 to 30% gravel. Subrounded, poorly sorted, brown.
Gravel content increases to 85% between 22.9 and 24.4 meters.

24.4 to 28.7 meters. Sandy, gravelly clay. 80% clay, 10% sand, 10% gravel. Sand and gravel are rounded, poor to moderately sorted, and brown to green. Clay is orange to gray.

28.7 to 32.6 meters. Argillite. 100% clay, well sorted, gray to green. No water.

WELL 104



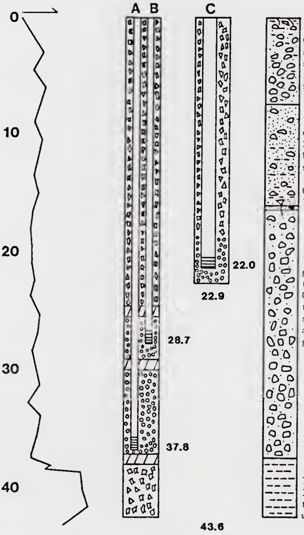
0 to 15.2 meters. Sandy gravel (organics and soil near too). 65 to 85% gravel, 5 to 35% sand, 5 to 20% pebbles, 2 to 5% clay. Rounded, poorly sorted, brown sand and clay; red, brown, green gravel.

Sand content decreases from 30 to 35% to 5 to 15% at 7.6 meters.

15.2 to 25.9 meters. Gravelly sand. 60 to 70% sand, 25 to 30% gravel, 5 to 10% pebbles, 1 to 2% clay. Rounded, poorly to moderately sorted, brown to gray sand and clay; red brown, green gravel and pebbles.

25.9 to 34.1 meters. Argillite. 100% clay. Weel sorted, medium to light green. Highly fractured. Producing water.

WELL 105



0 to 7.6 meters. Silty, sandy gravel. 10 to 35% sand, 5 to 30% silt, 1 to 2% clay. Subrounded to rounded, poorly sorted, light brown to gray.

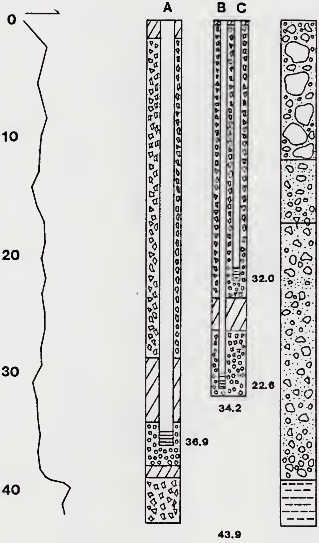
7.6 to 16.8 meters. Gravelly, clayey sand. 40 to 70% sand, 20 to 40% gravel, 2 to 15% clay. Rounded, moderate to poorly sorted, medium to light brown.

Clay content increases to 5 to 7% at 10.7 meters.

16.8 to 38.4 meters. Sandy gravel. 65 to 85% gravel, 10 to 15% pebbles, 0 to 5% silt, 0 to 5% clay. Rounded to subrounded, moderate to poorly sorted, brown to gray sand, silt and clay; red, brown, green gravel and pebbles.

38.4 to 43.6 meters. Argillite. 100% clay. Well sorted, medium to light green. Little to no water.

WELL 106



0 to 12.2 meters. Boulder field with a matrix of 10 to 85% gravel, 5 to 40% pebbles, and 0 to 85% sand. Little to no silts or clay. Pebbles and gravels are well rounded, sand is subrounded to rounded, poor to moderately sorted. Color varies from red to green to brown.

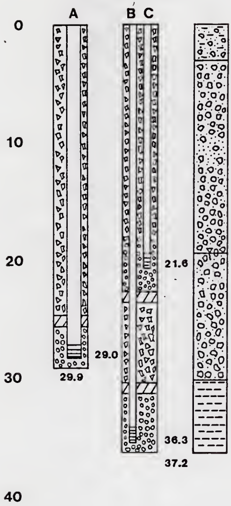
12.2 to 39.9 meters. Sandy, pebbly gravel. 50 to 90% gravel, 5 to 45% pebbles, 1 to 40% sand. Gravel and pebbles are well rounded, sand is subrounded to rounded, poor to moderately sorted. Color varies from red to green to brown.

Zones with high sand content (30 to 35%) from 18.3 to 21.3 meters. 80% sand at 22.9 meters.

Large rounded cobbles found in cuttings pile from 32.0 to 39.9 meters.

39.9 to 43.9 meters. Argillite. 100% clay. Well sorted, medium green. Little to no water.

WELL 107



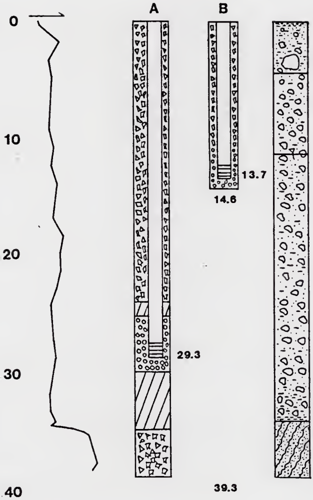
0 to 3.0 meters. Gravelly sand. 55 to 75% sand, 20 to 35% gravel, 3 to 10% silt. Rounded, moderately sorted, light brown.

3.0 to 30.8 meters. Sandy gravel. 50 to 80% gravel, 10 to 40% sand, 0 to 10% silt, 0 to 25% pebbles. Rounded to subrounded, moderate to poorly sorted. Brown to gray sand and silt; red, brown, green gravel and pebbles.

Zone with high sand content (85 to 95%) from 9.2 to 12.2 meters.

30.8 to 32.7 meters. Argillite. 100% clay. Well sorted, light to medium green. Little to no water.

WELL 108



0 to 4.6 meters. Clay rich soil and gravelly sand. 45% clay, 15 to 85% sand, 10 to 30% gravel. Gravel is rounded, sand is subangular to rounded, poorly sorted, dark to light brown.

Boulder between 3.0 and 3.7 meters.

4.6 to 32.0 meters. Clayey, sandy gravel. 50 to 80% gravel, 5 to 30% sand, 2 to 20% silt and clay. Gravel is rounded, sand is subrounded to rounded, poorly sorted. Color varies from red to brown to green.

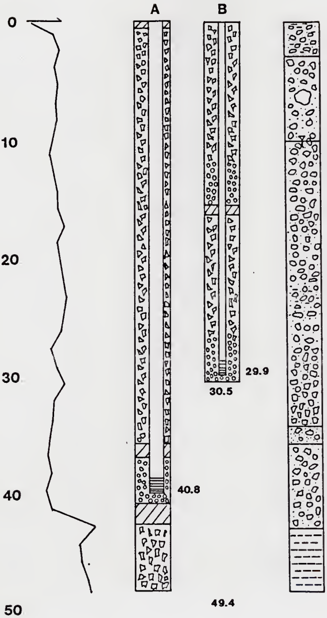
High silt and clay content at 21.3 meters.

32.0 to 34.8 meters. Clayey gravel, 60 to 70% sand, 10 to 15% clay. Sand and gravel are rounded, poorly sorted. Color varies from red to brown to green.

Clay layer from 34.4 to 34.8 meters.

34.8 to 39.3. Quartzite. Well sorted, purplish brown. Little to no water.

WELL 109



0 to 3.0 meters. Silty, sandy gravel. 60 to 80% gravel, 10 to 15% sand, 10 to 15% silt, 5 to 10% clay. Sand and gravel are rounded, poorly sorted, light to medium brown.

3.0 to 35.1 meters. Sandy gravel. 50 to 80% gravel, 5 to 60% pebbles and cobbles(mostly argillites and quartzites), 10 to 35% sand, < 10% silt and clay. Sand, gravel, and pebbles are rounded, moderate to poorly sorted, brown sand, silts, and clays; red, brown, green gravel and pebbles.

Large boulder between 6.1 to 7.3 meters.

Sand content increases to 20 to 25% between 16.8 and 19.8 meters.

Sand content increases to 50 to 65% and clay and silt increases to 10 to 15% between 22.9 to 25.9 meters.

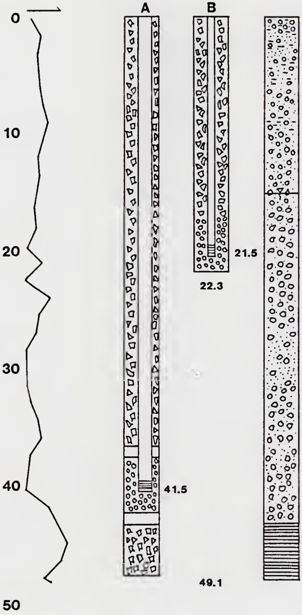
Pebble content increases to 45% between 29.0 and 33.5 meters.

35.1 to 36.6 meters. Gravelly sand. 55 to 60% sand, 30 to 40% gravel, 5 to 10% pebbles, <5% clay. Sand, gravel, and pebbles are rounded, poorly sorted, medium brown.

36.6 to 43.9. Sandy gravel. Description same as interval from 3.0 to 35.1 meters.

43.9 to 49.4 meters. Argillite. 100% clay. Well sorted, medium green. Little to no water.

WELL 110



0 to 1.5 meters. Sandy gravel. 75% gravel, 20% sand, < 5% silt, < 5% clay. Rounded, poorly sorted, medium brown.

3.0 to 6.1 meters. Clayey, gravelly sand. 30 to 50% sand, 35 to 50% gravel, 5 to 10% clay, 5 to 10% silt. Rounded, moderate to well sorted, medium brown.

6.1 to 44.2 meters. Sandy, clayey, pebbly gravel. 40 to 80% gravel, 10 to 40% sand, 5 to 35% pebbles, < 2 to 20% clay. Rounded, moderate to poorly sorted, brown sand and clay; red, brown, green gravel and pebbles.

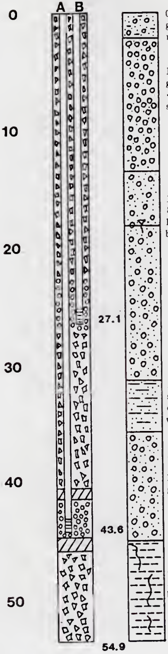
Zone with high clay content (20%) from 9.2 to 10.7 meters.

Zone with high sand content (35 to 55%) from 27.4 to 32.0 meters.

Zone with high sand content (35 to 45%) from 38.1 to 39.6 meters.

44.2 to 49.1 meters. Slate. 100% clay. Well sorted, dark gray to black. No water.

WELL 111



0 to 1.5 meters. Silty sand. 85% sand, 10% gravel, 5% silt, 2% clay. Rounded to subrounded, moderately sorted, medium brown.

1.5 to 13.7 meters. Gravel. 90 to 95% gravel, 1 to 10% sand, 1 to 5% pebbles, < 1% clay. Subrounded, well sorted, brown sand; red, brown, green gravel and pebbles.

13.7 to 32.0 meters. Sandy gravel. 65 to 85% gravel, 10 to 20% sand, 5 to 20% pebbles. Rounded, poorly sorted, brown sand; red, brown, green gravel and pebbles.

32.0 to 36.6 meters. Sand and clay. 50% sand, 50% clay. Sand is subrounded, moderately sorted, light brown to gray. No water.

36.6 to 46.0 meters. Sandy gravel. 60 to 70% gravel, 20 to 30% pebbles, 5 to 15% sand. Rounded, poorly sorted, brown sand; red, brown, green gravel and pebbles.

46.0 to 54.9 meters. Argillite. 100% clay. Well sorted, black to green. Heavily fractured. Fractures produce up to 100 gpm water.

SCHEMATIC DRAWING OF SANDPOINTS

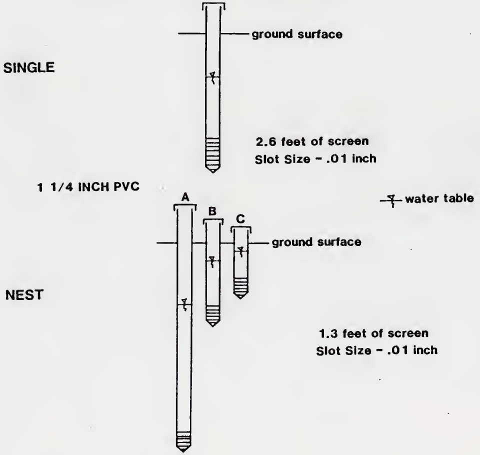


Table B1 : Sandpoint Depths

Sandpoint	Depth (ft)
113	9.10
114	9.50
115	9.50
116	10.20
117	10.50
118A	12.00
118B	8.00
118C	3.80
119A	14.20
119B	8.60
119C	2.80
120	5.99
121A	13.50
121B	7.00
121C	4.00
122A	14.40
122B	7.00
122C	3.00
123A	13.10
123B	7.50
123C	5.50
124	5.50
125	6.80
126	5.50
127	6.00
128	5.00
129	5.50
130	5.50
131	5.50
136	7.00

AQUIFER TEST ANALYSIS

To determine the hydrogeologic characteristics of transmissivity and hydraulic conductivity, aquifer tests were conducted at well sites 102, 103, 105, 106, 107, 108, 109 and 110. At each site the tests used wells constructed of open-ended eight inch diameter pipe completed to various depths in the aquifer. The depths of the test wells are shown in Appendix B as the total depth of the hole in which PVC wells labeled B are completed. All tests utilized only the production well; no observation wells were available. Water was pumped with a submersible pump set below projected test pumping levels. Pump discharge below 100 gpm was measured by operating a standard inline flow meter located in the discharge line at the well head. Discharge rates over 100 gpm were determined by using a three inch orifice plate and manometer attached to a four inch diameter discharge pipe. Water discharge during testing was channelled away from the site by plastic lined channels between 100 to 200 ft in length or by pipes 50 to 100 ft in length. Prior to the start of an aquifer test the pump was set and the well was pumped to determine the magnitude of drawdown to be expected, and to clean out and partially develop the well. Wells were then allowed to recover to original static water levels.

Both step drawdown tests and constant discharge tests were conducted on each well. Step tests at wells 102 and 105 followed the description of Walton (1962). Discharge was increased without recovery at approximately 30 min intervals for a total of three steps. Multi-rate constant discharge tests conducted on the other six wells consisted of pumping the wells for approximately 30 minutes at one rate and then shutting the pump off and allowing the well to fully recover. Afterwards the pump was turned on at a higher rate for 30 minutes, then shut off and again the well was allowed to

recover. This procedure was repeated a third time at a higher rate. Drawdown versus time measurements were collected during all testing and recovery data were collected where applicable. Discharge rates of steps varied from well to well, with a minimunnm of 20 gpm to a maximum of 254 gpm. A standard constant discharge test was conducted at all wells. For the six wells whose tests allowed for recovery between steps, the last constant discharge test continued for 2 to 4 hours or until the water level stablized. Constant discharge tests were conducted at wells 102 and 105 after the well recovered from the step test. Results of the tests showing field measurements of drawdown versus time are presented in Figures C1 and C10.

Analyses of aquifer test data were complicated by the use of the eight inch open ended steel casing wells. The drawdowns recorded during the tests for each well are composed of three components: 1) drawdown related to the properties of the formation and formation water; 2) drawdown related to the longer flow paths required to deliver water to the open ended casing (partial penetration effects) and 3) drawdown related to the flow of water into the open end of the casing (well loss). All field measurements of drawdown were first corrected for partial penetration effects. All aquifer tests either reached equilibrium or showed minimal head decline compared to the thickness of the aquifer by the end of the longer constant discharge test. This enabled usage of the following equation presented in Walton (1970) to correct the field drawdowns:

$$s = sp\ [\ Kp\ (\ 1 + 7\sqrt{rw/(2\ Kp\ m)}\ (\mathrm{Cos}\ (Kp\ II)/2)]$$

where:

s = drawdown corrected for partial penetration effects, ft
sp = field measured drawdown, ft
Kp= ratio of length of screen to saturated thickness of the aquifer, fraction (the length of the screen was modeled to be 1 ft for the open ended casing)
rw = radius of the pumping well, ft
m = saturated thickness of the aquifer, ft

Once data were corrected for the effects of partial penetration, the step drawdown data were evaluated using techniques developed by Walton (1962) and Nahm (1980) to correct the drawdown for the additional effects of well loss. After these drawdown corrections the Thiem equilibrium equation for wells penetrating water table aquifers was used to calculate the aquifer hydraulic conductivity (Fetter, 1980). The radial distance from the pumping well at which the drawdown equalled zero was estimated to be 100 ft. The aquifer tansmissivity was obtained by multiplying the hydraulic conductivity by the aquifer thickness.

REFERENCES CITED

Fetter, C. W. Jr., 1980, Applied hydrogeology. Charles E. Merril, Columbus, 488p.

Nahm, G. Y., 1980, Estimating transmissivity and well loss constants using multi-rate test data a from pumped well. Ground Water, Vol. 18, No. 3, pp. 281-285.

Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation. Ill. State Water Survey Bull. 49, 81p.

Walton, W. C., 1970, Groundwater resource evaluation. Mc Graw-Hill, 663p.

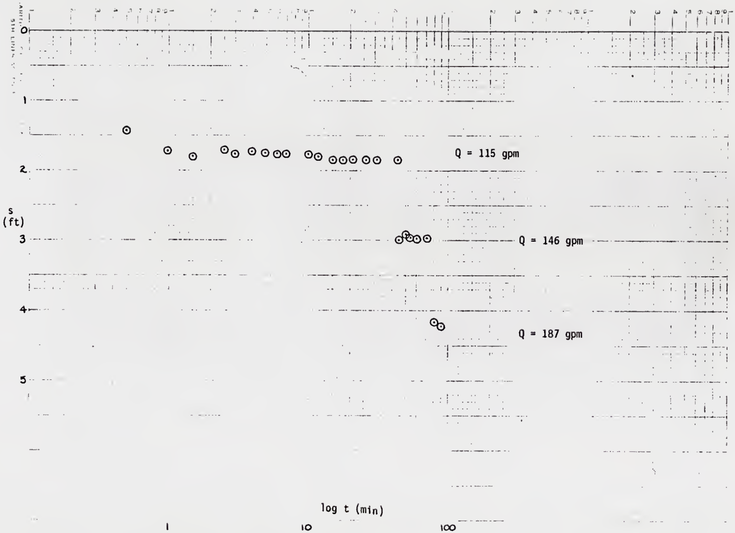


Figure C1: Step Drawdown Test - Well 102

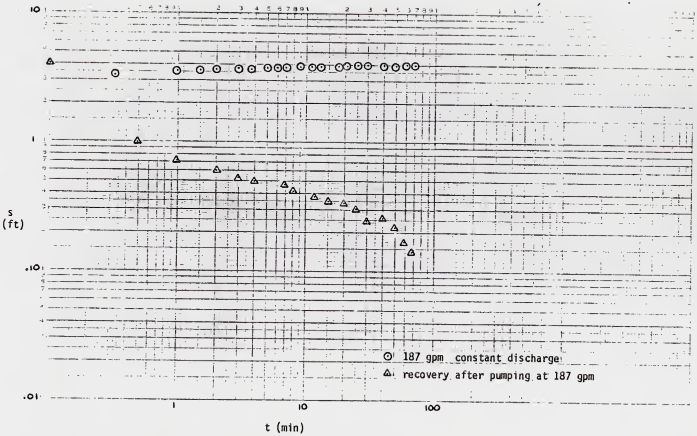


Figure C2: Constant Discharge Test - Well 102

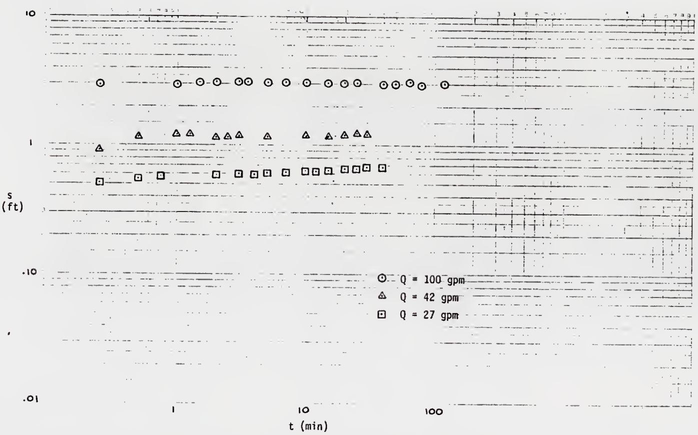


Figure C3: Multi-rate Constant Discharge Test - Well 103

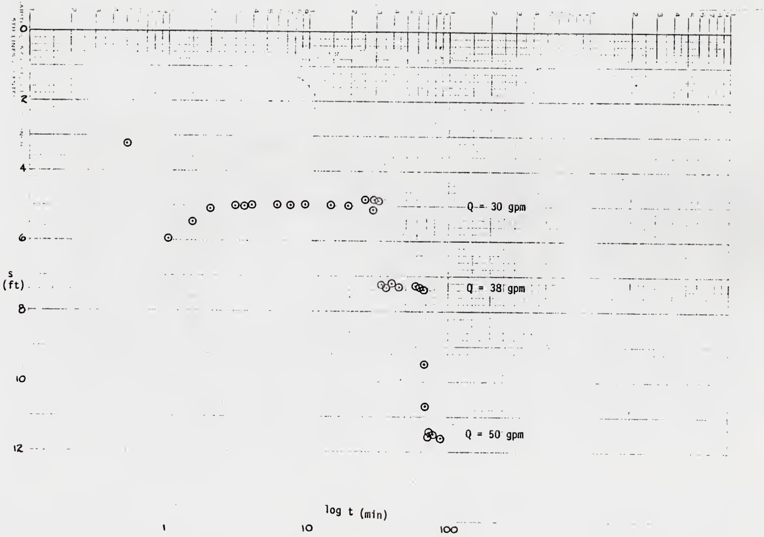


Figure C4: Step Drawdown Test - Well 105

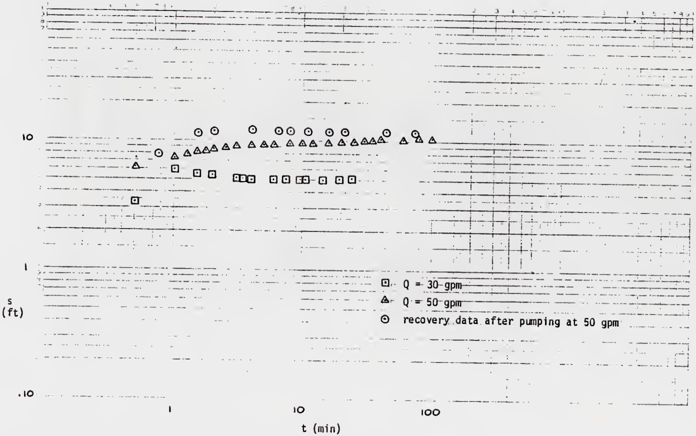


Figure C5: Constant Discharge Test - Well 105

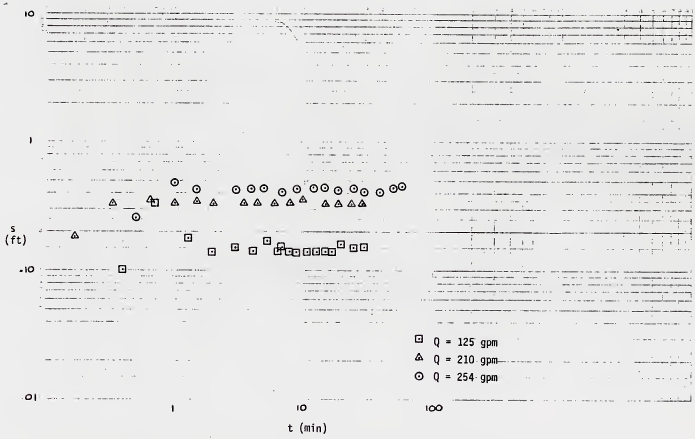


Figure C6: Multi-rate Constant Discharge Test - Well 106

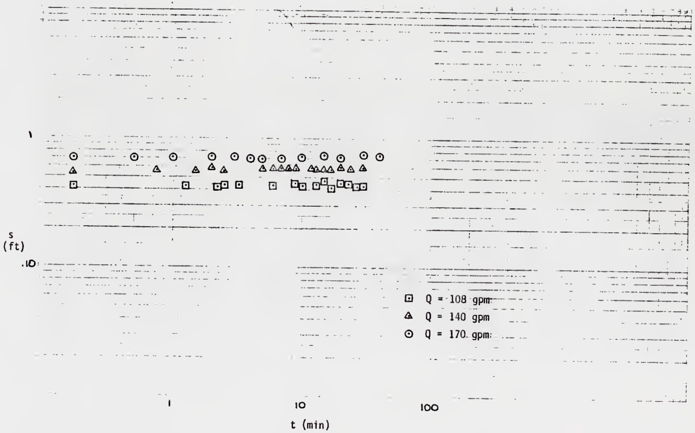


Figure C7: Multi-rate Constant Discharge Test - Well 107

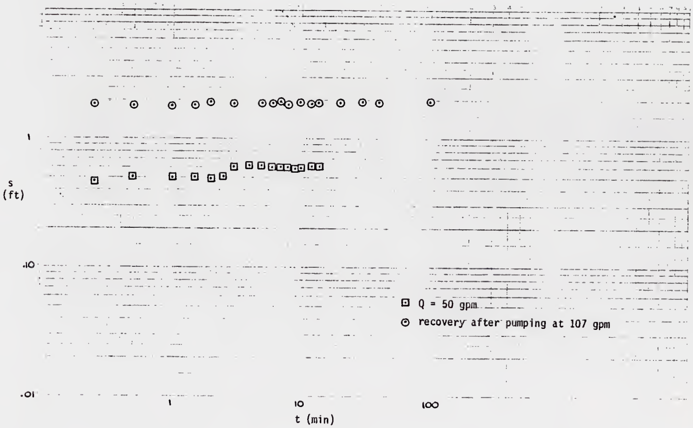


Figure C8: Multi-rate Constant Discharge Test - Well 108

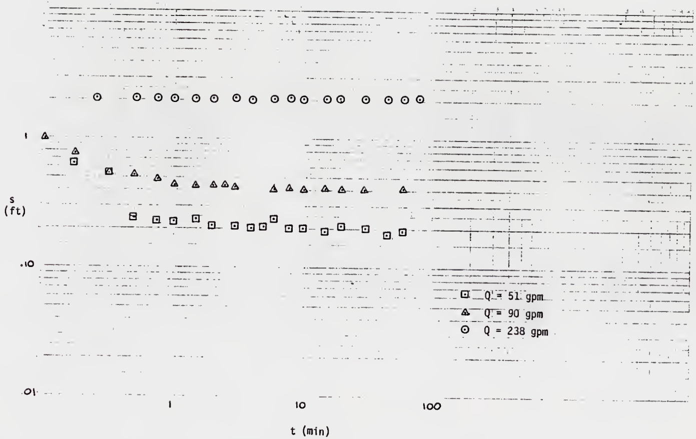


Figure C9: Multi-rate Constant Discharge Test - Well 109

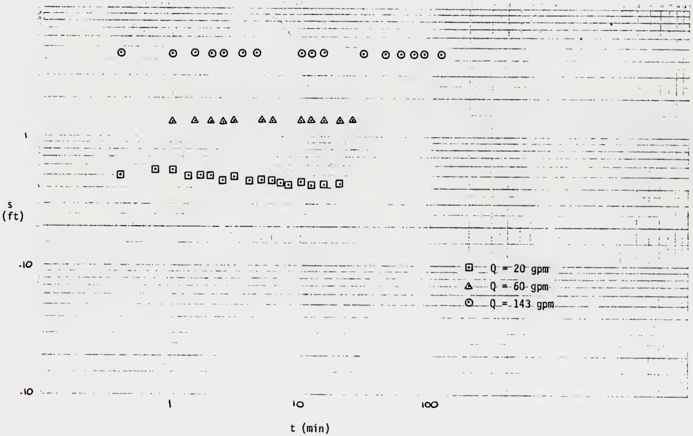


Figure C10: Multi-rate Constant Discharge Test - Well 110

APPENDIX D

WATER QUALITY DATA

TABLES OF WATER QUALITY SAMPLING RESULTS
FROM FEBRUARY 1982 THROUGH JUNE 1984

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
2	21	811201	0.0130	0.200	0.180	0.100	0.050	-9.0	-9.0	-9.0	45.0	1.6	43.0	8.6	-9.0	-9	-9.0	-9.00	-9.00	-9
2	22	820401	0.0090	0.100	0.190	-9.000	-9.000	4.2	71.0	181.0	41.5	1.9	43.2	8.8	8.5	-9	-9.0	7.50	-9.00	-9
2	93	830131	0.0089	0.691	0.100	0.288	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	331	-9.0	-9.00	-9.00	245
2	94	830324	0.0150	0.896	0.016	0.495	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.2	371	-9.0	-9.00	-9.00	282
2	95	830508	0.0110	0.564	0.018	0.100	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.5	382	-9.0	-9.00	-9.00	315
2	97	830713	0.0110	0.301	0.290	0.092	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	529	-9.0	-9.00	-9.00	420
2	182	830831	0.0069	0.625	0.299	0.059	0.000	3.1	66.4	180.1	10.3	2.3	54.9	12.8	10.5	362	329.9	7.60	8.00	265
2	368	831019	0.0050	-9.000	-9.000	-9.000	-9.000	3.3	56.6	178.4	11.5	2.4	50.7	12.7	10.0	401	317.4	7.40	7.80	290
2	465	831129	0.0042	1.000	0.180	0.075	7.800	3.1	49.2	180.0	9.6	1.8	50.8	18.2	8.0	390	308.7	7.80	7.80	270
2	768	840323	0.0080	0.452	0.230	0.037	-9.000	2.8	52.9	158.4	9.7	2.5	52.2	12.0	7.5	271	301.6	7.62	7.90	185
2	960	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	3.3	47.3	158.0	9.6	1.7	50.1	12.1	12.0	396	294.1	7.84	7.80	300
3	31	811201	0.0050	0.050	0.015	0.100	0.050	-9.0	-9.0	-9.0	10.1	2.0	51.0	15.3	-9.0	-9	-9.0	-9.00	-9.00	-9
3	184	830831	0.0011	0.000	0.004	0.007	0.000	0.6	2.5	163.3	3.6	1.2	31.8	12.0	17.0	234	215.0	8.50	8.40	200
6	6A	810518	0.3500	0.050	14.000	-9.000	-9.000	20.4	20.3	514.0	18.3	6.8	126.0	31.3	-9.0	-9	737.0	7.30	-9.00	-9
6	6B	810630	0.1900	-9.000	9.200	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6C	810706	0.1500	-9.000	8.400	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6D	810708	0.1500	-9.000	8.600	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6E	810828	0.2200	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6F	810929	-9.0000	-9.000	-9.000	-9.000	-9.000	14.3	26.0	464.0	25.7	7.0	106.0	23.2	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6G	810930	0.1400	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6H	811026	0.2600	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6I	811102	0.3700	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6J	811109	0.0002	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6K	811217	0.3880	0.200	9.900	0.200	0.050	-9.0	-9.0	-9.0	17.8	5.6	110.0	31.8	-9.0	-9	-9.0	-9.00	-9.00	-9
6	6L	820401	0.5400	0.180	8.650	-9.000	-9.000	9.0	6.2	600.0	19.0	5.5	128.4	29.2	7.0	-9	-9.0	7.00	-9.00	-9
6	1	821021	0.2940	0.227	7.320	0.212	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	830	-9.0	7.00	-9.00	830
6	2	821203	0.2960	0.460	7.420	0.962	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	840	-9.0	6.80	-9.00	840
6	3	830201	0.1570	0.064	5.730	0.694	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.8	569	-9.0	-9.00	-9.00	450
6	4	830324	0.2830	0.035	6.160	0.264	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.1	756	-9.0	-9.00	-9.00	560
6	5	830331	0.2740	0.354	-9.000	0.316	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	794	-9.0	-9.00	-9.00	580
6	7	830408	0.2830	0.345	-9.000	0.246	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	821	-9.0	-9.00	-9.00	600
6	8	830417	0.2990	0.421	-9.000	0.382	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	18.0	828	-9.0	-9.00	-9.00	720
6	9	830423	0.3890	0.388	5.520	0.179	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	22.0	856	-9.0	-9.00	-9.00	810
6	10	830507	0.4360	0.572	8.640	0.153	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	18.0	748	-9.0	-9.00	-9.00	650
6	11	830517	0.4730	0.431	-9.000	0.153	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.0	965	-9.0	-9.00	-9.00	630
6	12	830525	0.3730	0.457	8.330	0.318	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	890	-9.0	-9.00	-9.00	650
6	13	830601	0.2340	0.296	-9.000	0.111	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	830	-9.0	-9.00	-9.00	600
6	14	830614	0.1440	0.130	7.980	0.114	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	658	-9.0	-9.00	-9.00	510
6	15	830623	0.1500	0.421	-9.000	0.343	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	309	-9.0	-9.00	-9.00	240
6	16	830701	0.1130	0.330	5.550	0.255	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	429	-9.0	-9.00	-9.00	325
6	17	830708	0.1670	0.153	-9.000	0.103	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	16.0	598	-9.0	-9.00	-9.00	500
6	18	830713	0.2040	0.227	6.580	0.095	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	693	-9.0	-9.00	-9.00	550
6	19	830720	0.2470	0.034	-9.000	0.235	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	16.0	718	-9.0	-9.00	-9.00	600
6	150	830830	0.2610	0.708	7.697	0.067	0.000	14.5	23.7	440.9	21.5	3.9	96.9	25.5	11.5	776	626.6	7.10	7.50	580
6	274	830921	0.1650	0.381	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	737	-9.0	7.00	-9.00	600
6	296	831005	0.1530	0.201	5.394	0.098	-9.000	18.8	20.8	411.7	23.4	3.8	93.6	22.5	13.0	774	595.2	7.00	7.60	600
6	376	831020	0.1380	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	677	-9.0	8.40	-9.00	495
6	446	831128	0.1820	0.260	5.780	-9.000	-9.000	13.8	16.1	466.2	24.5	3.9	101.3	28.2	8.5	715	655.0	7.00	7.80	500
6	559	840126	0.0072	0.000	4.000	0.092	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	544	-9.0	7.35	-9.00	380

-9.00 - Analysis not requested

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
6	584	840221	0.0088	0.000	3.770	0.044	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	332	-9.0	7.08	-9.00	240
6	752	840321	0.1100	0.172	5.700	0.091	-9.000	11.5	18.4	473.5	24.5	3.8	105.0	25.9	9.0	920	663.7	7.12	-9.00	650
6	783	840424	0.3600	0.620	6.600	0.178	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	770	-9.0	7.12	-9.00	550
6	862	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	594	-9.0	7.15	-9.00	460
6	944	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	13.0	20.6	427.2	19.6	4.1	95.8	23.8	13.5	778	606.3	7.04	7.70	610
7	7A	811109	0.0020	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
7	7B	811201	0.0600	0.800	0.050	0.600	0.050	-9.0	-9.0	-9.0	140.0	1.2	7.5	3.0	-9.0	-9	-9.0	-9.00	-9.00	-9
7	7C	811201	0.0300	0.200	0.015	0.100	0.050	-9.0	-9.0	-9.0	155.0	0.8	0.1	0.0	-9.0	-9	-9.0	-9.00	-9.00	-9
7	7D	811201	0.0300	0.200	0.015	0.100	0.050	-9.0	-9.0	-9.0	160.0	0.8	0.2	0.0	-9.0	-9	-9.0	-9.00	-9.00	-9
7	20	821021	0.0250	0.428	0.092	2.191	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	740	-9.0	7.20	-9.00	740
7	21	821203	0.0220	0.592	0.169	2.452	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	835	-9.0	6.90	-9.00	835
7	22	830201	0.0330	0.464	0.076	1.142	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.7	522	-9.0	-9.00	-9.00	470
7	23	830324	0.0200	0.604	0.068	1.137	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	18.2	630	-9.0	-9.00	-9.00	550
7	24	830508	0.0330	0.778	0.915	1.376	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	21.0	1015	-9.0	-9.00	-9.00	940
7	25	830713	0.0230	1.100	0.867	0.170	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.0	1352	-9.0	-9.00	-9.00	1200
7	178	830830	0.0270	0.102	0.054	0.084	0.000	10.3	31.5	361.5	157.7	0.6	1.0	0.4	13.0	574	563.0	7.30	7.70	445
7	273	830921	0.0273	0.828	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	18.0	632	-9.0	7.20	-9.00	550
7	304	831005	0.0270	0.040	0.121	0.304	-9.000	10.1	32.8	340.0	150.0	0.6	0.8	0.5	12.0	727	536.4	7.10	7.90	550
7	379	831020	0.0310	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	609	-9.0	7.00	-9.00	445
7	463	831129	0.0160	1.100	1.280	0.300	-9.000	10.0	28.1	349.6	60.0	2.0	33.0	27.0	11.0	576	510.7	7.50	8.10	426
8	8A	811102	0.0390	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
8	8B	811201	0.3960	0.800	6.900	0.300	0.050	-9.0	-9.0	-9.0	19.0	5.3	92.0	27.8	-9.0	-9	-9.0	-9.00	-9.00	-9
8	8C	811217	0.5100	1.050	6.870	0.130	0.010	-9.0	-9.0	-9.0	19.0	6.3	92.0	26.0	-9.0	-9	-9.0	-9.00	-9.00	-9
8	8D	820401	0.3900	0.100	7.250	-9.000	-9.000	13.1	6.6	539.0	22.7	5.1	123.8	23.6	9.0	-9	-9.0	7.20	-9.00	-9
8	26	821021	0.1820	0.024	3.520	0.243	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	780	-9.0	6.90	-9.00	780
8	27	821203	0.3330	0.058	12.890	0.362	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	850	-9.0	6.70	-9.00	850
8	28	830201	0.2150	0.389	-9.000	0.079	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	18.0	771	-9.0	-9.00	-9.00	670
8	29	830324	0.2830	0.098	6.260	0.110	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	692	-9.0	-9.00	-9.00	500
8	30	830423	0.5440	1.300	7.660	0.064	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	737	-9.0	-9.00	-9.00	600
8	31	830507	0.2910	0.537	6.820	0.111	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	20.0	552	-9.0	-9.00	-9.00	500
8	32	830524	0.2970	0.353	6.800	0.037	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.0	872	-9.0	-9.00	-9.00	540
8	33	830601	0.2400	0.403	-9.000	0.022	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	710	-9.0	-9.00	-9.00	550
8	34	830614	0.2340	0.545	5.710	0.030	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	720	-9.0	-9.00	-9.00	520
8	35	830623	0.1990	0.687	-9.000	0.510	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	645	-9.0	-9.00	-9.00	500
8	36	830701	0.2370	0.625	6.510	0.048	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	378	-9.0	-9.00	-9.00	300
8	37	830708	0.2300	0.230	-9.000	0.030	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	675	-9.0	-9.00	-9.00	550
8	38	830713	0.1530	0.611	6.310	0.014	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	16.0	718	-9.0	-9.00	-9.00	600
8	39	830820	0.1290	0.423	-9.000	0.016	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	798	-9.0	-9.00	-9.00	650
8	152	830830	0.1120	0.502	8.197	0.014	0.000	12.8	8.4	494.0	22.5	4.7	105.7	26.1	17.5	697	674.2	7.15	7.50	600
8	272	830921	0.1840	0.258	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	17.0	786	-9.0	7.04	-9.00	670
8	308	831005	0.3100	1.300	8.694	0.030	-9.000	11.0	5.0	503.8	20.8	5.2	108.7	26.4	15.0	798	682.5	7.08	7.60	650
8	375	831020	0.3640	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	17.0	786	-9.0	8.55	-9.00	670
8	750	840321	0.0580	1.960	5.500	0.061	-9.000	8.0	14.8	462.8	18.9	3.6	101.0	25.9	5.0	684	636.1	7.26	7.70	435
8	958	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	8.7	16.1	418.4	20.7	4.0	88.9	22.8	14.0	756	581.6	7.24	7.60	600
9	9A	811102	0.3800	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
9	9B	811201	0.4400	1.300	0.015	0.050	0.050	-9.0	-9.0	-9.0	185.0	0.9	0.2	0.1	-9.0	-9	-9.0	-9.00	-9.00	-9
9	9C	820401	0.5100	9.140	6.980	-9.000	-9.000	6.5	0.7	551.0	20.6	5.1	111.3	24.7	8.0	-9	-9.0	6.80	-9.00	-9
9	40	821021	0.7030	11.000	6.310	0.806	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	780	-9.0	7.05	-9.00	780
9	41	821203	0.6580	18.000	8.290	0.114	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	820	-9.0	6.90	-9.00	820

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
9	42	830131	0.6130	24.000	6.330	0.057	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	1470	-9.0	-9.00	-9.00	1050
9	43	830324	0.6320	17.000	7.860	0.073	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.5	701	-9.0	-9.00	-9.00	550
9	44	830331	0.7470	14.000	-9.000	0.077	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	676	-9.0	-9.00	-9.00	500
9	45	830408	0.7700	9.400	-9.000	0.063	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	727	-9.0	-9.00	-9.00	550
9	46	830417	0.7260	16.000	-9.000	0.087	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.5	718	-9.0	-9.00	-9.00	550
9	47	830423	0.8250	14.000	8.550	0.080	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	16.0	580	-9.0	-9.00	-9.00	485
9	49	830508	0.7610	11.000	6.410	0.179	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	706	-9.0	-9.00	-9.00	510
9	50	830517	0.4780	12.000	-9.000	0.101	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	708	-9.0	-9.00	-9.00	500
9	51	830525	0.5440	9.000	5.100	0.070	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.5	797	-9.0	-9.00	-9.00	500
9	52	830601	0.6190	9.200	-9.000	0.023	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	298	-9.0	-9.00	-9.00	200
9	53	830614	0.5700	11.000	-9.000	0.083	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	710	-9.0	-9.00	-9.00	550
9	54	830623	0.3170	12.000	6.430	0.036	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	162	-9.0	-9.00	-9.00	120
9	55	830701	0.5700	12.000	-9.000	0.321	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	761	-9.0	-9.00	-9.00	550
9	56	830708	0.4580	12.000	6.080	0.127	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.5	701	-9.0	-9.00	-9.00	550
9	58	830713	0.5300	12.000	7.870	0.138	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	793	-9.0	-9.00	-9.00	600
9	59	830720	0.8050	10.000	-9.000	0.153	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	756	-9.0	-9.00	-9.00	600
9	154	830830	0.5270	9.500	8.197	0.113	0.000	4.3	0.5	542.0	18.2	5.2	112.0	24.9	11.5	776	706.6	7.11	7.40	580
9	276	830921	0.5520	8.900	8.398	0.114	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.5	918	-9.0	5.65	-9.00	720
9	302	831005	0.5180	11.000	6.594	0.074	-9.000	4.7	1.0	504.6	17.2	4.9	106.6	24.3	11.0	778	663.9	7.03	7.40	575
9	310	831005	0.5540	9.900	6.594	0.127	-9.000	4.7	1.0	505.1	16.9	4.8	105.8	34.4	12.5	784	663.3	6.98	7.50	600
9	374	831020	0.5270	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	770	-9.0	8.70	-9.00	550
9	472	831130	0.1040	12.000	6.780	0.100	-9.000	4.9	0.5	487.6	17.6	4.6	102.3	27.0	6.0	727	645.0	7.19	7.70	475
9	557	840126	0.5900	12.930	7.300	0.200	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	854	-9.0	7.17	-9.00	550
9	756	840323	0.6900	12.960	7.300	0.191	-9.000	4.5	0.5	534.7	19.2	4.8	111.0	27.5	6.0	996	702.8	7.12	7.50	650
9	782	840424	0.6200	13.000	7.500	0.118	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	991	-9.0	7.18	-9.00	700
9	868	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	439	-9.0	7.37	-9.00	310
9	946	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	5.6	0.5	541.6	18.9	5.3	104.0	28.3	12.0	925	702.1	7.21	7.40	700
10	10A	811201	0.2240	0.100	0.015	0.050	0.050	-9.0	-9.0	-9.0	27.0	5.7	7.1	21.0	-9.0	-9	-9.0	-9.00	-9.00	-9
10	10B	820401	0.3100	0.050	0.020	-9.000	-9.000	9.6	23.0	405.0	31.5	6.2	89.8	18.9	9.0	-9	-9.0	7.30	-9.00	-9
10	60	821021	0.2050	0.322	0.039	0.085	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	770	-9.0	6.95	-9.00	770
10	61	821203	0.2180	0.136	0.008	0.016	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	850	-9.0	6.70	-9.00	850
10	63	830131	0.2940	0.000	0.030	0.032	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	529	-9.0	-9.00	-9.00	400
10	64	830324	C.2260	0.000	0.053	0.016	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.1	599	-9.0	-9.00	-9.00	444
10	65	830417	0.1380	0.945	-9.000	0.264	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	17.0	575	-9.0	-9.00	-9.00	490
10	66	830423	0.1670	0.082	0.626	0.022	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	604	-9.0	-9.00	-9.00	480
10	67	830508	0.1460	0.107	0.564	0.055	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.0	574	-9.0	-9.00	-9.00	510
10	68	830517	0.1410	0.461	-9.000	0.038	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	629	-9.0	-9.00	-9.00	465
10	69	830523	0.1440	0.055	0.637	0.101	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	623	-9.0	-9.00	-9.00	450
10	70	830601	0.1360	0.173	-9.000	0.059	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.5	637	-9.0	-9.00	-9.00	500
10	71	830614	0.1700	0.062	0.983	0.082	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	664	-9.0	-9.00	-9.00	480
10	73	830623	0.1650	0.073	-9.000	0.036	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	577	-9.0	-9.00	-9.00	470
10	74	830701	0.2130	0.651	0.413	0.163	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	581	-9.0	-9.00	-9.00	450
10	75	830708	0.1920	0.024	-9.000	0.034	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.5	582	-9.0	-9.00	-9.00	480
10	76	830713	0.2010	0.005	0.028	0.018	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	617	-9.0	-9.00	-9.00	490
10	77	830720	0.2520	0.024	-9.000	0.009	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	614	-9.0	-9.00	-9.00	500
10	156	830830	0.1720	0.021	0.645	0.007	0.028	11.3	18.8	391.9	28.6	4.6	79.8	21.0	11.5	575	556.0	7.14	7.90	430
10	271	830921	0.2410	0.016	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	1246	-9.0	6.85	-9.00	900
10	306	831005	0.1690	0.005	0.294	0.012	-9.000	10.9	18.8	394.9	26.5	5.0	84.0	19.9	11.5	622	561.6	7.02	7.60	465
10	373	831020	0.2090	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	637	-9.0	7.50	-9.00	460

Well	Samp	Data	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
10	450	831128	0.1160	0.025	0.209	0.088	-9.000	7.9	12.9	401.3	30.2	5.4	79.0	22.8	7.0	606	560.5	7.41	7.70	407
10	758	840323	0.1800	0.072	0.160	0.000	-9.000	12.0	23.2	396.9	28.6	4.9	84.0	22.0	8.5	644	572.7	7.12	7.50	450
10	948	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	13.0	12.6	458.0	34.6	4.8	87.0	20.8	12.0	925	589.0	7.21	7.60	700
11	11A	811201	0.0260	1.800	3.300	0.050	0.050	-9.0	-9.0	-9.0	10.2	2.6	63.0	15.2	-9.0	-9	-9.0	-9.00	-9.00	-9
11	118	820401	0.0110	0.910	2.830	-9.000	-9.000	4.2	68.0	216.0	10.1	2.8	68.6	13.4	9.0	-9	-9.0	7.30	-9.00	-9
11	78	830131	0.0200	0.754	2.730	0.036	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	403	-9.0	-9.00	-9.00	295
11	79	830508	0.0200	0.890	0.027	0.032	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	1256	-9.0	-9.00	-9.00	950
11	80	830713	0.0180	0.603	2.730	0.028	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	390	-9.0	-9.00	-9.00	295
11	158	830830	0.0150	1.000	2.997	0.004	0.000	3.4	56.8	210.9	10.0	2.7	66.0	12.9	13.0	413	362.7	7.42	7.90	320
11	270	830921	0.0120	0.656	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	1118	-9.0	7.20	-9.00	750
11	372	831020	0.0180	0.600	2.187	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	412	-9.0	7.20	-9.00	285
11	510	831101	0.0220	1.500	2.480	0.061	-9.000	3.5	39.5	228.1	10.7	2.6	58.5	15.0	8.5	422	358.9	-9.00	7.90	295
17	17A	811201	0.0050	0.050	0.030	0.050	0.050	-9.0	-9.0	-9.0	8.0	1.8	48.0	14.6	-9.0	-9	-9.0	-9.00	-9.00	-9
17	17B	820401	0.0220	0.025	0.005	-9.000	-9.000	3.8	45.0	192.0	7.7	1.7	54.3	13.2	10.0	-9	-9.0	7.70	-9.00	-9
17	98	830324	0.0018	0.024	0.001	0.716	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.2	345	-9.0	-9.00	-9.00	245
17	99	830508	0.0018	0.020	0.002	0.363	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	337	-9.0	-9.00	-9.00	255
17	180	830831	0.0017	0.002	0.005	0.040	0.000	2.9	34.0	174.6	7.2	1.8	43.8	12.9	10.5	335	272.2	7.64	8.00	245
17	284	830922	0.0010	0.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	339	-9.0	6.38	-9.00	240
17	370	831019	0.0013	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	357	-9.0	7.35	-9.00	255
17	461	831129	0.0007	0.003	0.003	0.050	-9.000	3.1	35.6	177.7	7.9	2.0	45.4	14.4	6.8	337	287.1	7.51	8.10	225
18	18A	811201	0.0050	0.300	0.015	0.050	0.050	-9.0	-9.0	-9.0	3.8	0.9	24.0	10.0	-9.0	-9	-9.0	-9.00	-9.00	-9
18	162	830830	0.0000	0.000	0.001	0.038	0.000	1.0	6.7	142.9	3.8	1.0	28.3	9.9	8.0	217	193.6	7.46	7.90	150
19	19A	811201	0.0050	0.050	0.015	0.500	0.050	-9.0	-9.0	-9.0	4.5	1.1	31.0	11.9	-9.0	-9	-9.0	-9.00	-9.00	-9
19	19B	820401	0.0010	0.025	0.005	-9.000	-9.000	2.0	7.5	163.0	4.4	1.0	36.0	10.9	12.5	-9	-9.0	7.80	-9.00	-9
19	100	830713	0.0014	0.023	0.008	0.125	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	208	-9.0	-9.00	-9.00	170
19	160	830830	0.0010	0.000	0.002	0.138	0.000	1.0	5.4	138.8	9.2	1.3	27.6	9.6	10.0	207	187.9	7.47	7.80	150
19	556	840126	0.0000	0.000	0.000	0.150	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	260	-9.0	7.60	-9.00	180
19	586	840223	0.0000	0.000	0.000	0.150	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	195	-9.0	7.64	-9.00	135
19	770	840323	0.0000	0.000	0.000	0.121	-9.000	1.8	7.7	161.1	4.8	1.2	36.0	11.7	7.5	271	225.4	7.62	8.00	185
19	781	840424	0.0000	0.000	0.000	0.148	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	236	-9.0	7.45	-9.00	165
19	867	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	166	-9.0	7.75	-9.00	115
19	952	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	1.6	5.9	149.2	4.4	1.7	30.8	10.1	9.0	247	205.7	7.46	7.80	175
20	20A	811201	0.0045	0.050	0.015	0.050	0.050	-9.0	-9.0	-9.0	10.7	3.0	60.0	14.3	-9.0	-9	-9.0	-9.00	-9.00	-9
20	101	830508	0.0052	0.031	0.002	0.007	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	406	-9.0	-9.00	-9.00	290
20	102	830713	0.0048	0.061	0.005	0.018	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	330	-9.0	-9.00	-9.00	250
20	212	830901	0.0040	0.129	0.001	0.002	0.000	2.9	45.0	201.8	9.5	1.8	55.6	12.1	11.5	388	328.7	7.59	7.80	290
20	281	830922	0.0046	0.170	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	383	-9.0	7.15	-9.00	290
20	366	831019	0.0025	-9.000	-9.000	-9.000	-9.000	3.1	38.8	202.8	10.0	2.7	52.8	12.6	10.0	394	324.6	7.25	7.90	285
21	224	830901	0.0017	0.005	0.001	0.086	0.060	4.0	31.5	189.1	7.6	1.7	46.8	14.3	15.0	294	295.0	7.57	8.00	240
23	23A	811201	0.0050	0.050	0.060	0.300	0.050	-9.0	-9.0	-9.0	9.1	2.1	54.0	15.1	-9.0	-9	-9.0	-9.00	-9.00	-9
23	234	830901	0.0006	0.000	0.001	0.013	0.032	2.8	52.8	185.5	8.7	2.1	53.8	12.7	16.0	365	318.4	7.63	8.00	305
24	238	830901	0.0007	0.000	0.001	0.020	0.030	2.9	52.3	184.9	8.8	2.1	53.9	12.9	11.0	311	317.7	7.55	8.00	230
25	226	830901	0.0006	0.011	0.001	0.046	0.000	3.2	41.5	192.8	7.5	1.8	50.5	13.6	15.0	362	310.9	7.67	8.10	295
26	228	830901	0.0012	0.000	0.001	0.070	0.031	3.0	49.0	193.7	8.1	2.0	52.5	13.6	12.0	376	321.9	7.65	8.00	285
27	230	830901	0.0010	0.000	0.001	0.148	0.018	3.0	49.0	191.4	8.1	1.9	52.4	13.6	13.0	1033	319.4	7.62	8.20	800
28	28A	820401	0.0020	0.025	0.005	-9.000	-9.000	3.7	70.0	189.0	9.6	2.3	62.6	13.1	15.5	-9	-9.0	7.40	-9.00	-9
28	232	830901	0.0016	0.005	0.000	0.130	0.000	3.0	61.0	192.3	9.0	2.3	62.5	12.0	19.0	332	342.1	7.63	8.10	295
29	204	830831	0.0005	0.011	2.497	0.014	0.005	1.6	5.5	175.1	4.9	1.6	35.7	11.3	10.0	221	235.7	7.52	7.90	160
30	116	830811	0.0000	0.000	0.005	0.135	0.053	2.6	5.5	158.7	6.1	1.4	36.4	9.9	10.8	244	230.6	-9.00	7.80	180

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
30	202	830831	0.0011	0.000	0.001	0.112	0.041	2.1	5.1	167.7	5.6	2.1	35.4	10.3	9.5	392	228.3	7.53	8.00	280
35	467	831129	0.0000	0.080	0.000	0.025	-9.000	1.1	3.5	66.6	3.6	1.1	9.5	5.5	6.0	114	91.9	6.82	7.80	75
36	469	831129	0.0000	0.025	0.000	0.025	-9.000	0.8	3.5	148.2	4.1	0.9	31.6	8.1	8.0	231	198.2	7.41	7.80	160
A	A1	811109	0.0010	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
B	81	811109	0.0010	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
B	103	821021	0.0027	0.000	0.000	0.138	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	330	-9.0	7.15	-9.00	330
B	166	830830	0.0015	0.000	0.001	0.100	0.005	1.2	9.4	185.5	4.2	1.7	38.8	12.1	15.0	258	252.9	7.58	8.00	210
C	C1	811109	0.0010	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C1	C11	811201	0.0150	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C1	186	830831	0.0080	1.100	0.744	0.013	0.000	0.5	2.1	166.9	3.5	0.9	33.4	10.7	20.0	253	218.0	7.56	7.70	230
C2	C21	811201	0.0025	-9.000	-9.000	-9.000	-9.000	1.5	14.0	162.0	4.0	1.0	34.8	11.1	13.0	-9	-9.0	7.50	-9.00	-9
C2	C22	820401	0.0010	0.005	0.005	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C2	104	830713	0.0012	0.000	0.003	0.934	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	568	-9.0	-9.00	-9.00	430
C2	194	830831	0.0010	0.000	0.002	0.241	0.036	1.0	5.5	132.9	4.0	1.8	26.6	9.0	18.5	205	180.8	7.41	7.90	180
C2	282	830922	0.0010	0.010	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	227	-9.0	8.05	-9.00	185
C2	355	831018	0.0000	0.005	0.000	0.138	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.5	228	-9.0	7.32	-9.00	175
C2	448	831128	0.0007	0.025	0.003	0.200	-9.000	1.4	6.0	150.1	4.4	1.2	28.2	11.6	7.7	245	203.9	7.33	8.10	168
C2	561	840127	0.0000	0.000	0.000	0.120	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.0	242	-9.0	7.47	-9.00	150
C2	588	840223	0.0000	0.000	0.000	0.140	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.0	210	-9.0	7.40	-9.00	130
C2	762	840323	0.0000	0.000	0.000	0.110	-9.000	1.1	7.0	148.9	4.2	1.0	31.2	10.9	6.5	249	205.4	7.49	7.90	165
C2	802	840504	0.0000	0.000	0.000	0.168	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	219	-9.0	7.51	-9.00	153
C2	865	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	110	-9.0	7.76	-9.00	75
C2	938	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.1	5.5	125.2	4.0	1.0	25.1	8.8	8.5	314	172.7	6.82	7.90	220
C3	C31	811201	0.0025	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C3	C32	820401	0.0010	0.025	0.005	-9.000	-9.000	1.7	21.0	170.0	6.4	1.2	40.7	11.7	18.5	-9	-9.0	7.30	-9.00	-9
C3	192	830831	0.0010	0.000	0.025	0.043	0.012	1.2	17.5	158.3	6.0	1.8	35.8	10.8	14.5	248	231.4	7.53	8.00	200
C4	C41	811201	0.0050	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C4	C42	820401	0.0010	0.080	0.010	-9.000	-9.000	3.4	6.0	162.0	6.3	1.2	34.5	10.8	13.0	-9	-9.0	7.30	-9.00	-9
C4	200	830831	0.0007	0.029	0.016	0.558	0.000	1.9	5.1	140.2	5.1	1.1	28.4	9.4	8.5	272	191.2	7.27	7.90	190
C5	C51	811201	0.0190	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C6	C61	811201	0.0025	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C6	188	830831	0.0012	0.000	0.001	0.274	0.015	0.4	6.0	136.7	4.1	0.9	27.6	9.1	13.0	193	184.8	7.45	8.00	150
C8	C81	811201	0.0025	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
C8	196	830831	0.0017	0.000	0.001	0.070	0.089	1.9	21.4	166.0	6.4	1.9	38.7	11.0	11.5	287	247.3	7.65	7.90	215
C21	C211	811201	0.0025	0.200	0.015	0.900	0.050	-9.0	-9.0	-9.0	5.6	1.2	38.0	12.6	-9.0	-9	-9.0	-9.00	-9.00	-9
C21	198	830831	0.0010	0.000	0.001	0.924	0.000	1.5	17.5	155.1	5.7	1.9	35.1	10.6	19.0	225	227.4	7.53	7.70	200
D	D1	820118	0.0010	0.040	0.005	0.020	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
D	D2	820401	0.0020	0.050	0.005	-9.000	-9.000	5.9	37.0	239.0	9.0	1.8	64.4	14.4	10.5	-9	-9.0	7.60	-9.00	-9
D	81	821021	0.0020	0.074	0.003	0.067	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	440	-9.0	7.30	-9.00	440
D	83	830201	0.0018	0.005	0.000	0.079	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.2	354	-9.0	-9.00	-9.00	263
D	84	830506	0.0018	0.042	0.003	0.055	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	16.5	657	-9.0	-9.00	-9.00	600
D	85	830713	0.0020	0.085	0.022	0.026	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	348	-9.0	-9.00	-9.00	270
D	168	830830	0.0010	0.051	0.001	0.002	0.000	2.9	35.7	192.1	8.3	1.6	47.6	13.4	9.0	346	301.7	7.62	7.95	245
D	275	830921	0.0015	0.038	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	369	-9.0	7.34	-9.00	270
D	299	831005	0.0025	0.042	0.017	0.042	-9.000	3.2	32.8	193.7	7.4	1.7	50.2	13.0	11.5	347	303.2	7.22	7.90	260
D	371	831019	0.0025	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	17.0	375	-9.0	7.81	-9.00	320
D	474	831130	0.0007	0.025	0.000	0.025	-9.000	3.4	36.0	199.6	9.7	1.8	49.6	15.1	8.5	379	316.2	7.78	8.10	265
D	760	840321	0.0000	0.000	0.000	0.000	-9.000	3.1	29.6	197.8	7.8	1.7	50.4	13.7	9.0	389	304.2	7.78	8.00	275
D	950	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	3.4	26.4	193.6	7.9	1.8	47.4	12.9	11.0	351	295.5	7.59	8.00	260

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
E	172	830830	0.0018	0.000	0.001	0.027	0.005	1.2	6.1	182.4	1.5	2.0	38.4	12.0	16.5	230	243.6	7.47	7.60	210
F	F1	820118	0.0010	0.040	0.005	0.210	0.030	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
F	176	830930	0.0009	0.000	0.001	0.031	0.005	1.9	14.5	186.0	6.2	1.5	42.9	12.1	9.0	304	265.1	7.53	7.60	215
G	G1	750616	-9.0000	-9.000	-9.000	-9.000	-9.000	5.8	38.6	379.0	13.0	-9.0	89.0	25.2	-9.0	-9	551.0	-9.00	-9.00	-9
G	105	821013	0.0430	5.500	3.503	0.026	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	710	-9.0	7.00	-9.00	710
G	120	830816	0.0680	8.400	4.397	0.008	0.000	20.4	10.0	546.1	39.2	3.0	108.7	28.1	-9.0	-9	755.5	-9.00	7.20	-9
G	560	840127	0.0460	0.227	2.062	0.329	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	849	-9.0	-9.00	-9.00	600
G	587	840223	0.0630	2.840	3.980	0.098	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	420	-9.0	7.06	-9.00	420
G	764	840323	0.0720	5.370	4.090	0.000	-9.000	15.9	5.1	620.8	43.2	2.8	119.0	33.8	9.0	1062	842.9	7.06	7.40	750
G	803	840504	0.0930	6.760	4.120	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	609	-9.0	7.22	-9.00	440
G	866	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	470	-9.0	7.21	-9.00	320
G	940	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	19.8	11.8	554.8	44.6	3.3	89.0	32.1	11.0	1015	757.1	6.39	7.50	750
H	86	821021	0.0050	0.102	0.002	0.141	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	550	-9.0	7.20	-9.00	550
H	87	821203	0.0020	0.023	0.004	0.127	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	460	-9.0	7.20	-9.00	460
H	88	830131	0.0022	0.017	0.023	0.085	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	365	-9.0	-9.00	-9.00	270
H	89	830324	0.0020	0.022	0.006	0.115	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.8	361	-9.0	-9.00	-9.00	260
H	90	830508	0.0013	0.034	0.014	0.147	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	357	-9.0	-9.00	-9.00	255
H	91	830601	0.0016	0.015	-9.000	0.128	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	1315	-9.0	-9.00	-9.00	950
H	92	830712	0.0019	0.000	0.014	0.115	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.0	348	-9.0	-9.00	-9.00	270
H	164	830830	0.0014	0.000	0.002	0.130	0.005	3.1	37.4	200.1	8.4	1.5	50.8	13.2	11.0	277	314.5	7.60	7.90	205
H3	H31	811201	0.0020	0.100	0.010	0.400	0.020	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
H3	220	830901	0.0011	0.005	0.001	0.002	0.042	3.5	40.0	192.8	93.2	0.7	0.3	0.0	17.0	358	330.5	7.51	8.10	305
H4	H41	811217	0.0010	0.140	0.005	0.350	0.030	3.7	48.0	194.0	8.5	2.2	51.9	16.2	-9.0	-9	324.0	7.90	-9.00	-9
H4	222	830901	0.0007	0.005	0.001	0.240	0.030	3.1	38.6	194.1	7.4	1.7	49.8	14.0	16.0	377	308.7	7.54	8.00	315
H8	H81	811217	0.0010	0.170	0.005	0.190	0.040	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
H8	214	830901	0.0010	0.012	0.001	0.107	0.019	3.1	42.7	195.2	8.2	1.4	52.2	13.5	12.0	363	316.4	7.56	7.90	275
I	I1	820118	0.0010	0.010	0.005	0.110	0.020	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
J	J1	750616	-9.0000	-9.000	-9.000	-9.000	-9.000	4.6	81.0	295.0	11.0	-9.0	87.0	19.8	-9.0	-9	619.0	7.84	-9.00	-9
J	122	830816	0.0057	1.000	3.897	0.004	0.000	5.6	36.0	322.7	15.0	2.8	77.1	18.6	-9.0	-9	477.8	-9.00	7.50	-9
J	354	831018	0.0025	8.300	1.787	0.127	-9.000	5.8	27.8	324.8	14.7	2.7	77.2	18.8	9.5	553	473.6	4.75	7.80	395
L	174	830831	0.0014	0.023	0.005	0.195	0.000	1.2	7.7	205.5	4.7	1.5	44.4	13.3	16.0	255	278.3	7.51	7.60	213
M16	M161	811217	0.0020	0.200	0.005	0.280	0.010	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
M16	206	830831	0.0013	0.000	0.006	0.282	0.012	0.5	5.7	159.2	3.5	1.6	33.3	11.1	16.5	219	214.9	7.55	8.00	200
M16	774	840323	0.0000	0.000	0.000	0.191	-9.000	1.0	7.3	148.6	4.4	1.2	31.2	10.8	5.0	259	205.6	7.90	8.20	165
M16	956	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	0.4	0.5	112.6	2.3	1.1	32.6	7.7	14.0	195	148.7	7.86	8.00	155
M17	117	830816	0.0010	0.050	0.112	0.000	0.000	8.3	0.5	87.1	8.0	1.3	18.0	4.5	17.0	-9	127.2	-9.00	9.10	-9
M17	385	831021	0.0025	0.012	0.067	0.000	-9.000	6.7	0.5	85.7	7.1	1.3	16.7	5.5	11.5	153	124.9	9.32	9.20	115
99	522	831206	0.0150	0.120	0.047	0.000	-9.000	4.5	36.8	199.9	9.4	2.2	50.4	14.9	7.5	374	319.2	8.03	8.40	255
99	524	831206	0.0030	0.025	0.380	0.000	-9.000	4.2	51.5	195.0	11.1	2.3	52.8	14.8	6.0	406	332.7	7.86	8.20	265
99A	552	840126	0.0000	0.000	0.162	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	372	-9.0	7.70	-9.00	260
99A	579	840221	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	346	-9.0	7.01	-9.00	245
99A	710	840320	0.0000	0.000	0.000	0.000	-9.000	3.4	30.0	198.6	6.6	1.7	49.2	15.0	13.5	306	306.8	7.13	7.70	240
99A	796	840503	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	354	-9.0	7.61	-9.00	250
99A	854	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	214	-9.0	7.61	-9.00	170
99A	890	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	3.6	26.6	196.4	9.2	1.6	48.8	13.4	5.0	338	301.6	7.32	7.90	215
998	553	840126	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	357	-9.0	7.64	-9.00	250
998	578	840221	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	346	-9.0	7.01	-9.00	245
998	712	840320	0.0000	0.000	0.000	0.000	-9.000	3.3	31.6	198.6	8.6	1.6	48.6	14.7	9.0	339	308.4	7.63	7.80	240
998	797	840503	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	235	-9.0	7.55	-9.00	170

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
998	856	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	291	-9.0	7.66	-9.00	215
99B	894	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	3.6	27.7	194.8	9.2	1.6	48.0	13.2	7.0	327	300.1	7.32	8.00	220
100A	M52	831019	0.0800	0.135	4.387	0.000	-9.000	4.2	5.8	431.7	13.2	7.8	88.6	23.4	9.5	588	576.5	-9.00	8.40	420
100A	M54	831019	0.0230	-9.000	-9.000	-9.000	-9.000	4.3	6.9	496.2	15.1	8.8	98.3	30.4	12.5	758	661.8	-9.00	8.40	580
100A	M56	831019	0.0670	0.018	2.787	0.000	-9.000	4.6	7.2	500.6	14.3	5.5	103.2	30.5	10.5	712	667.7	-9.00	8.40	520
100A	512	831202	0.0290	0.400	2.980	0.025	-9.000	4.8	10.2	481.0	13.7	8.6	84.8	41.8	6.1	916	561.2	7.31	8.00	600
100A	906	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	4.6	0.5	627.2	16.1	6.4	127.0	38.1	13.0	968	821.4	7.14	7.40	750
100B	508	831201	0.4120	5.600	3.280	0.025	-9.000	4.2	5.9	379.5	14.8	3.7	80.5	21.0	1.5	584	510.6	7.33	8.30	340
101A	M48	831018	0.4270	2.200	6.587	0.000	-9.000	4.0	0.5	530.7	14.2	6.4	114.5	27.4	11.0	690	699.0	6.85	8.10	510
101A	M50	831018	0.4280	-9.000	-9.000	-9.000	-9.000	4.1	0.5	558.2	16.3	5.5	110.4	28.5	9.0	835	724.8	6.85	8.10	590
101A	502	831202	0.1450	0.025	5.680	0.025	-9.000	75.0	426.0	771.5	348.0	11.2	96.0	46.0	5.0	1794	1779.0	8.25	8.10	1140
101A	861	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	1489	-9.0	7.67	-9.00	1100
101B	119	830816	0.7040	17.000	10.997	0.012	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
101B	277	830921	0.7460	13.000	9.998	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
101B	312	831005	0.7370	19.000	9.894	0.012	-9.000	4.0	1.0	577.2	13.1	5.6	130.9	27.6	11.0	839	760.0	6.81	7.40	620
101B	383	831021	0.7080	15.000	9.587	0.012	-9.000	2.6	0.5	572.0	14.2	5.1	122.4	29.8	10.0	927	747.9	6.96	7.50	670
101B	500	831201	0.6340	15.000	8.780	0.000	-9.000	3.9	0.5	529.7	14.8	5.0	100.9	28.6	4.5	741	683.9	7.01	7.90	465
101B	563	840127	0.8840	22.920	9.362	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	814	-9.0	7.12	-9.00	575
101B	582	840221	0.8600	16.940	9.080	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	269	-9.0	6.82	-9.00	190
101B	736	840321	0.8610	17.870	9.490	0.000	-9.000	3.7	0.5	564.7	12.7	5.3	122.0	29.8	9.0	991	740.3	6.82	7.20	700
101B	801	840503	0.8230	17.860	9.920	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	-9	-9.0	7.23	-9.00	-9
101B	860	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	554	-9.0	6.81	-9.00	400
101B	904	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	3.9	0.5	622.2	15.2	5.4	125.0	36.2	12.0	991	828.1	7.01	7.50	750
102A	M59	831019	0.3190	-9.000	-9.000	-9.000	-9.000	4.4	0.5	451.3	13.9	5.5	96.4	23.3	11.5	495	596.6	-9.00	8.10	370
102A	M61	831019	0.2490	-9.000	-9.000	-9.000	-9.000	5.5	6.8	379.4	22.3	5.0	74.7	20.5	11.0	541	516.0	-9.00	8.40	400
102A	M63	831019	0.4130	0.018	4.787	0.000	-9.000	7.0	6.9	468.8	35.2	6.3	88.9	22.8	10.0	630	637.7	-9.00	8.20	455
102A	M57	831019	0.2160	6.000	3.687	0.024	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.0	617	-9.0	-9.00	-9.00	490
102A	506	831201	0.6310	8.400	5.980	0.063	-9.000	4.7	0.5	393.5	18.7	5.1	78.6	23.6	8.0	636	525.2	6.95	8.10	440
102B	M65	831020	0.3430	-9.000	-9.000	-9.000	-9.000	4.6	1.8	459.2	14.4	6.9	96.8	23.9	12.5	594	609.4	7.15	8.30	455
102B	M67	831020	0.3000	-9.000	-9.000	-9.000	-9.000	4.5	0.5	457.5	17.6	6.7	93.8	23.8	10.0	644	605.7	7.50	8.10	465
102B	M69	831020	0.4010	-9.000	-9.000	-9.000	-9.000	5.7	0.5	457.5	17.4	5.7	95.2	23.8	9.5	651	607.1	7.40	8.10	465
102B	MP71	831024	0.7670	10.000	6.087	0.031	-9.000	5.0	0.5	456.9	16.7	4.6	96.6	23.9	8.0	629	605.5	6.60	7.70	435
102B	MP73	831024	0.7340	-9.000	-9.000	-9.000	-9.000	4.7	0.5	454.1	16.7	4.6	94.5	24.2	7.5	639	600.6	6.65	7.70	435
102B	MP75	831024	0.7250	-9.000	-9.000	-9.000	-9.000	4.9	0.5	453.5	17.0	4.6	96.6	23.7	10.0	644	602.1	6.45	7.70	465
102B	MP77	831024	0.7330	-9.000	-9.000	-9.000	-9.000	4.9	0.5	453.5	17.1	4.6	94.5	24.0	10.5	642	600.4	6.59	7.70	469
102B	MP79	831024	0.7000	-9.000	-9.000	-9.000	-9.000	5.1	1.8	446.7	17.6	4.6	94.5	23.4	10.5	628	595.3	6.80	7.60	459
102B	MP80	831024	0.6000	10.000	5.787	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	602	-9.0	6.80	-9.00	440
102B	504	831201	0.6210	12.000	5.880	0.800	-9.000	5.0	1.3	417.2	15.6	5.1	83.9	22.6	6.0	559	551.7	7.05	7.90	365
102B	562	840127	0.9740	19.920	6.362	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	616	-9.0	7.21	-9.00	445
102B	581	840221	1.1000	27.940	6.880	0.021	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	396	-9.0	6.89	-9.00	280
102B	732	840321	0.7710	38.870	5.990	0.000	-9.000	7.9	9.8	355.4	13.0	4.7	75.5	18.5	8.0	470	487.1	7.09	7.10	325
102B	800	840503	0.8530	41.860	6.320	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	-9	-9.0	7.14	-9.00	-9
102B	859	840529	-9.0000	0.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	351	-9.0	6.87	-9.00	260
102B	924	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	10.7	4.2	383.8	12.3	5.8	81.2	19.8	14.0	693	519.8	6.44	7.30	550
103A	M31	831007	0.0120	0.000	1.395	0.000	-9.000	5.6	12.6	276.9	11.4	5.5	62.8	13.4	12.0	429	389.8	7.98	8.40	325
103A	M34	831007	0.0200	0.000	2.195	0.012	-9.000	4.6	52.0	324.5	13.9	4.0	83.1	19.5	12.0	542	503.2	7.93	8.30	410
103A	457	831129	0.0007	0.700	0.980	0.000	-9.000	30.6	199.2	566.9	216.0	10.3	58.0	23.1	7.0	1401	1109.0	8.21	8.30	940
103B	M36	831010	0.0035	0.000	1.195	0.000	-9.000	5.2	46.5	304.4	14.1	4.0	75.0	19.5	12.5	359	470.9	7.70	8.20	275
103B	M38	831010	0.0220	0.091	2.395	0.012	-9.000	4.6	48.8	334.1	13.6	3.6	85.2	19.1	10.0	567	510.6	8.27	8.20	410

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
103B	MP57	831014	0.0310	0.015	2.287	0.066	-9.000	4.9	48.0	334.4	14.8	3.6	86.8	20.4	10.6	553	514.7	6.91	8.10	405
103B	MP59	831014	0.0290	-9.000	-9.000	-9.000	-9.000	4.8	48.0	335.6	14.4	3.5	87.1	20.2	9.5	567	515.4	6.88	8.00	405
103B	MP61	831014	0.0356	-9.000	-9.000	-9.000	-9.000	4.8	47.2	335.0	14.4	3.4	87.2	20.2	9.5	567	514.0	7.14	8.00	405
103B	MP63	831014	0.0350	-9.000	-9.000	-9.000	-9.000	4.8	43.6	338.4	14.2	3.4	87.0	20.1	10.0	623	513.3	7.11	7.90	450
103B	MP65	831014	0.0390	0.118	2.287	0.012	-9.000	4.8	43.5	337.9	14.2	3.4	87.0	20.0	9.8	535	512.6	6.94	8.10	385
103B	459	831129	0.0240	0.200	2.280	0.025	-9.000	4.0	36.5	273.9	12.3	2.8	67.2	16.8	4.5	398	414.5	7.21	7.90	250
103B	718	840320	0.0000	0.340	2.090	0.000	-9.000	3.6	30.0	262.2	12.0	2.8	63.2	15.2	11.0	365	391.3	7.43	7.80	270
103B	902	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	4.7	12.0	358.8	13.9	3.9	76.8	21.6	13.0	458	493.7	7.34	7.80	355
104A	MP85	831027	0.0060	0.005	0.894	0.012	-9.000	5.5	40.0	308.8	13.6	3.5	75.0	19.5	12.0	529	466.9	7.81	8.20	400
104A	MP87	831027	0.0025	-9.000	-9.000	-9.000	-9.000	6.1	37.2	288.4	15.0	3.6	69.2	21.0	12.0	575	441.5	8.25	8.40	435
104A	MP89	831027	0.0025	0.005	1.694	0.000	-9.000	6.1	37.0	294.3	15.1	3.9	67.2	21.5	12.5	562	446.2	8.31	8.30	430
104A	910	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	12.7	3.4	375.6	15.1	4.9	76.8	23.4	11.0	500	513.9	6.14	7.30	370
104B	438	831128	0.0163	0.200	3.080	0.025	-9.000	10.9	18.2	452.6	20.0	4.2	94.6	26.8	7.5	632	628.3	7.42	8.10	430
104B	555	840126	0.0040	0.000	2.162	0.014	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	426	-9.0	7.51	-9.00	295
104B	580	840221	0.0160	0.186	3.080	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	415	-9.0	7.30	-9.00	300
104B	720	840320	0.0000	0.110	3.490	0.000	-9.000	7.1	19.4	417.7	19.8	3.8	92.5	23.4	11.5	622	586.0	7.38	7.70	465
104B	798	840503	0.0100	0.000	3.720	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	588	-9.0	7.39	-9.00	430
104B	857	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	467	-9.0	7.34	-9.00	380
104B	908	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	7.5	26.4	387.6	19.2	3.7	84.2	24.1	12.0	515	554.7	6.18	7.90	390
105A	M71	831024	0.0025	0.012	1.487	0.000	-9.000	12.3	21.7	374.1	24.0	5.7	79.5	23.6	10.0	567	541.7	7.94	8.50	410
105A	M73	831024	0.0025	-9.000	-9.000	-9.000	-9.000	4.9	34.4	233.5	11.1	2.3	59.2	15.0	9.5	420	362.2	7.32	8.40	300
105A	M75	831024	0.0025	-9.000	-9.000	-9.000	-9.000	4.0	60.1	193.8	10.9	2.6	56.4	14.0	9.0	417	343.6	7.50	8.20	295
105A	M77	831024	0.0025	0.005	0.800	0.000	-9.000	3.8	59.0	199.5	10.9	2.3	57.6	14.2	10.5	410	349.1	7.40	8.20	300
105A	432	831128	0.0007	0.025	0.928	-9.000	-9.000	2.8	56.8	193.1	11.2	2.2	54.0	14.7	7.0	387	335.8	7.22	7.90	260
105B	M78	831025	0.0025	-9.000	-9.000	-9.000	-9.000	8.9	31.0	327.1	21.6	4.2	65.8	21.1	17.0	528	480.7	8.28	8.10	450
105B	M81	831025	0.0025	-9.000	-9.000	-9.000	-9.000	5.0	2.2	442.7	18.7	4.5	91.4	22.7	10.6	471	589.0	8.32	7.60	345
105B	M82	831026	0.0025	-9.000	0.008	0.084	-9.000	6.5	36.3	273.8	12.8	2.6	64.8	17.7	9.7	474	415.5	7.60	8.00	340
105B	M84	831026	0.0025	-9.000	-9.000	-9.000	-9.000	7.6	33.2	278.4	14.5	2.7	65.1	18.1	12.0	330	420.6	7.62	8.10	250
105B	M86	831026	0.0025	-9.000	-9.000	-9.000	-9.000	7.3	34.1	285.2	15.1	2.5	68.2	18.5	12.6	499	431.9	7.50	8.00	383
105B	M88	831026	0.0025	-9.000	-9.000	-9.000	-9.000	7.8	33.2	294.8	15.5	2.6	70.5	18.7	13.5	510	441.1	7.51	8.40	400
105B	M90	831026	0.0025	-9.000	-9.000	-9.000	-9.000	7.9	33.0	300.6	16.0	2.6	71.9	19.2	10.0	529	444.3	7.34	7.90	382
105B	M92	831026	0.0025	0.005	0.120	0.033	-9.000	8.5	31.5	306.1	16.6	2.6	74.0	19.2	10.0	526	459.5	7.29	8.00	380
105B	434	831128	0.0007	0.025	0.000	0.025	-9.000	2.6	38.4	204.5	9.6	2.0	51.4	14.8	8.0	376	324.3	7.37	8.00	260
105B	551	840126	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	374	-9.0	7.73	-9.00	255
105B	577	840221	0.0000	0.000	0.044	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	393	-9.0	7.60	-9.00	260
105B	708	840320	0.0000	0.000	0.000	0.258	-9.000	3.1	36.8	202.3	9.6	1.8	50.8	14.4	9.0	375	322.9	7.62	7.70	265
105B	795	840503	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	356	-9.0	7.77	-9.00	252
105B	853	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	243	-9.0	7.66	-9.00	180
105B	889	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	4.2	30.8	206.8	10.2	2.0	52.1	13.5	5.0	338	321.4	7.32	7.80	215
105C	436	831128	0.0007	0.025	0.780	0.025	-9.000	9.1	28.1	341.9	20.5	2.5	71.2	22.1	7.0	551	496.4	7.25	8.50	370
106A	M1	830912	0.0004	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.5	334	-9.0	7.36	-9.00	300
106A	M2	830912	0.0007	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.5	301	-9.0	7.78	-9.00	225
106A	M3	830913	0.0002	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	13.2	321	-9.0	8.46	-9.00	250
106A	346	831018	0.0000	0.005	0.099	0.063	-9.000	4.3	20.1	167.4	12.0	1.6	38.1	11.4	9.0	332	256.7	7.22	7.90	235
106A	478	831130	0.0007	0.025	0.280	0.025	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	294	-9.0	7.62	-9.00	195
106A	571	840130	0.0000	0.397	0.000	0.013	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	264	-9.0	7.71	-9.00	185
106A	585	840223	0.0000	0.000	0.000	0.019	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	3.0	215	-9.0	7.44	-9.00	130
106A	704	840320	0.0000	0.000	0.040	0.000	-9.000	3.9	12.5	150.6	6.9	1.7	33.1	10.9	5.5	217	221.9	7.35	7.80	140
106A	794	840503	0.0000	0.000	0.000	0.063	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	202	-9.0	7.96	-9.00	140

Well	Samp	Date	As	Fa	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
106A	852	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	164	-9.0	7.40	-9.00	120
106A	886	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	2.4	13.5	149.6	6.3	1.5	33.0	10.6	4.9	260	218.9	7.48	7.70	165
106B	M4	830913	0.0008	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	14.5	342	-9.0	7.46	-9.00	275
106B	M5	830913	0.0014	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	273	-9.0	-9.00	-9.00	200
106B	MP1	830915	0.0012	0.038	0.012	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9	-9.0	-9.00	-9.00	-9
106B	MP2	830915	0.0010	0.323	0.071	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.0	276	-9.0	7.66	-9.00	245
106B	344	831018	0.0025	0.025	0.120	0.025	-9.000	1.9	17.8	162.9	5.7	1.2	37.8	11.8	9.5	294	240.9	7.20	8.00	210
106B	480	831130	0.0007	0.025	0.000	0.025	-9.000	1.9	22.0	171.4	6.4	1.3	39.0	12.6	6.5	309	255.9	7.74	8.10	205
106C	342	831018	0.0025	0.005	0.041	0.012	-9.000	2.4	7.1	232.3	7.7	1.7	50.7	13.7	10.5	369	317.4	6.81	7.70	270
106C	482	831130	0.0007	0.025	0.000	0.000	-9.000	1.8	19.0	170.0	6.0	1.3	38.4	12.6	6.5	302	250.1	7.46	8.20	200
106C	572	840130	0.0000	0.000	0.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	276	-9.0	7.46	-9.00	195
106C	576	840221	0.0000	0.000	0.002	0.045	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.5	-9	-9.0	6.42	-9.00	80
106C	706	840320	0.0000	0.000	0.000	0.158	-9.000	5.2	8.4	158.0	6.8	1.7	34.2	11.2	6.5	-9	227.8	6.93	7.90	90
106C	793	840503	0.0000	0.000	0.000	0.182	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	-9	-9.0	7.29	-9.00	78
106C	852	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	-9	-9.0	7.30	-9.00	140
106C	968	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	6.3	3.6	299.5	10.2	2.0	64.2	18.6	4.5	-9	406.4	7.08	7.70	215
107A	M16	831005	0.1480	0.073	3.395	0.012	-9.000	10.1	6.2	477.9	18.2	5.8	102.6	25.3	9.5	616	642.7	8.10	8.30	440
107A	M18	831005	0.3120	0.000	7.095	0.012	-9.000	8.0	2.9	513.0	16.3	5.4	108.4	26.8	8.0	680	682.4	8.04	8.40	470
107A	M20	831005	0.3580	0.015	4.995	0.012	-9.000	14.6	3.3	491.0	28.2	5.9	98.4	24.9	8.0	694	667.9	7.92	8.30	480
107A	M22	831005	0.2980	0.022	3.895	0.012	-9.000	13.4	1.9	473.3	26.8	5.6	93.6	24.0	7.5	683	640.2	7.70	8.10	465
107A	348	831018	0.1050	0.300	4.187	0.002	-9.000	12.3	6.2	464.5	25.9	5.2	99.8	24.5	9.5	770	640.2	6.79	7.70	550
107A	451	831129	0.2110	3.200	4.780	0.600	-9.000	10.8	10.3	485.7	27.7	5.9	92.9	27.9	8.5	515	662.2	7.27	8.10	360
107A	716	840320	0.0540	1.070	3.290	0.368	-9.000	9.6	19.3	402.0	22.3	4.2	87.6	22.0	11.0	-9	569.3	7.18	7.70	445
107A	896	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	7.9	12.5	453.6	20.2	1.6	98.0	23.7	9.0	-9	622.3	7.18	7.60	450
107B	M23	831006	0.0560	0.000	3.295	0.012	-9.000	9.2	6.1	447.9	16.7	5.7	95.4	23.7	11.0	656	606.3	7.82	8.30	485
107B	M25	831006	0.1060	0.005	4.595	0.000	-9.000	7.0	1.0	456.5	15.5	5.9	94.8	23.5	10.0	644	604.8	7.78	8.20	465
107B	M27	831006	0.3500	0.000	4.395	0.000	-9.000	12.9	1.6	484.4	26.2	5.7	100.3	24.3	9.5	910	656.8	7.46	8.20	650
107B	M29	831006	0.3560	0.074	4.495	0.000	-9.000	12.4	1.8	481.0	26.0	5.5	98.8	24.2	9.0	849	651.3	7.37	8.00	600
107B	MP51	831012	0.5090	6.600	4.695	0.012	0.000	12.0	1.9	484.7	25.4	4.9	98.8	24.3	11.5	802	653.6	6.88	7.60	600
107B	MP52	831012	0.4100	5.100	4.595	0.012	0.000	12.5	3.6	474.6	25.2	4.9	97.8	24.2	10.0	775	644.4	6.83	7.60	560
107B	M39	831013	0.4430	5.500	4.595	0.012	-9.000	12.6	2.8	378.3	24.9	4.9	98.8	24.2	8.5	744	648.1	6.86	7.70	520
107B	M41	831013	0.4380	4.400	4.295	0.012	0.005	12.7	5.0	469.2	25.5	5.0	97.4	24.1	9.5	784	640.5	6.90	7.50	560
107B	M43	831013	0.4370	4.400	4.195	0.012	0.005	12.7	6.8	458.8	25.1	4.9	95.6	23.7	9.5	588	629.2	7.04	7.50	420
107B	M45	831013	0.3720	-9.000	-9.000	-9.000	-9.000	12.4	8.2	454.5	25.9	4.9	95.2	23.9	9.5	700	625.0	7.11	7.80	500
107B	350	831018	0.0025	0.027	0.487	0.012	-9.000	46.4	236.0	751.2	373.0	19.5	25.1	12.3	9.5	1610	1465.3	7.55	8.30	1150
107B	453	831129	0.0007	0.800	0.380	0.025	-9.000	43.8	246.0	766.0	416.0	17.6	15.1	11.4	7.5	1308	1526.0	8.04	8.40	890
107B	898	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	60.4	326.7	904.8	499.0	21.4	32.1	14.8	8.0	-9	1861.2	7.04	8.20	1500
107C	352	831018	0.7660	7.000	4.987	0.012	-9.000	7.5	7.9	484.5	19.3	4.8	103.2	26.5	10.0	830	655.5	4.85	7.50	600
107C	455	831129	0.0230	0.240	2.280	0.025	-9.000	10.7	18.4	400.9	25.8	4.0	82.3	24.8	9.0	672	567.9	7.25	7.90	475
107C	714	840320	0.3610	3.470	4.890	0.308	-9.000	6.1	6.8	519.3	16.8	4.9	112.0	28.0	10.5	-9	696.2	7.03	7.40	700
107C	900	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	7.9	12.4	454.4	19.8	4.8	97.4	23.8	11.0	-9	622.5	7.26	7.60	365
108A	M6	830915	0.0008	-9.000	0.210	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.5	265	-9.0	7.93	-9.00	219
108A	M7	830915	0.0012	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	311	-9.0	7.67	-9.00	225
108A	359	831019	0.0025	0.005	0.120	0.012	-9.000	3.8	44.2	183.7	15.4	3.4	42.3	14.3	8.5	372	308.9	7.55	8.10	260
108A	514	831202	0.0007	0.025	0.000	0.025	-9.000	3.4	31.6	183.6	10.4	2.1	43.2	14.1	7.0	365	289.4	8.10	8.40	245
108B	M8	830915	0.0006	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	294	-9.0	7.66	-9.00	215
108B	MP3	830916	0.0008	0.000	0.005	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	288	-9.0	7.42	-9.00	235
108B	357	831019	0.0250	0.005	0.000	0.012	-9.000	2.0	22.1	173.3	6.0	1.2	40.5	12.3	8.0	318	259.2	7.60	7.60	220
108B	516	831202	0.0007	0.025	0.000	0.000	-9.000	2.0	37.1	173.5	6.6	1.8	41.8	14.8	8.0	303	278.6	7.67	7.90	210

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
108B	700	840320	0.0000	0.000	0.000	0.000	-9.000	2.4	18.4	167.8	5.9	1.2	39.1	12.4	9.5	-9	249.5	7.58	7.80	200
108B	964	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	2.4	13.7	170.0	6.1	1.3	37.0	12.1	7.0	-9	244.6	7.66	8.00	190
109A	M9	830916	0.0014	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	17.5	255	-9.0	7.92	-9.00	220
109A	M10	830916	0.0012	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	219	-9.0	7.52	-9.00	160
109A	M11	830916	0.0014	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	235	-9.0	7.62	-9.00	170
109A	M12	830919	0.0002	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	332	-9.0	8.17	-9.00	240
109A	365	831019	0.0025	0.030	0.487	0.000	-9.000	2.1	3.6	161.3	5.9	1.3	32.3	10.4	10.0	256	218.7	6.91	7.70	185
109A	518	831202	0.0007	0.025	0.005	0.025	-9.000	2.3	4.7	156.9	5.9	1.5	31.7	11.1	6.0	252	215.1	7.41	7.90	165
109B	M13	830920	0.0014	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.5	254	-9.0	7.96	-9.00	190
109B	M14	830920	0.0016	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	229	-9.0	7.36	-9.00	160
109B	MP4	830921	0.0014	0.372	0.012	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	231	-9.0	7.21	-9.00	175
109B	363	831019	0.0000	0.050	0.487	0.000	-9.000	2.1	3.9	161.3	5.9	1.3	32.3	10.4	7.0	253	219.0	7.35	7.70	170
109B	520	831202	0.0007	0.240	0.580	0.000	-9.000	2.0	4.3	163.7	6.0	1.3	33.3	11.3	5.2	255	222.9	7.62	8.10	163
109B	550	840126	0.0000	0.000	0.262	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.5	-9	-9.0	6.79	-9.00	180
109B	575	840221	0.0000	0.000	0.226	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	7.36	-9.00	175
109B	702	840320	0.0000	0.000	0.040	0.000	-9.000	2.4	5.2	160.5	6.2	1.2	32.6	11.4	9.0	-9	221.8	7.41	7.70	185
109B	792	840503	0.0000	0.000	0.355	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	7.56	-9.00	180
109B	B50	840529	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	6.83	-9.00	150
109B	966	840625	-9.0000	-9.000	-9.000	-9.000	-9.000	2.3	5.9	151.2	6.4	1.3	30.6	10.5	5.0	-9	210.2	7.34	7.90	145
110A	M104	831031	-9.0000	0.005	1.294	0.000	-9.000	2.9	29.8	197.2	10.1	3.1	49.6	11.9	11.0	351	305.6	8.26	8.20	260
110A	M106	831031	0.0140	0.005	0.494	0.000	-9.000	2.9	45.3	174.1	9.8	2.4	50.4	11.6	12.0	343	297.5	7.72	8.30	260
110A	M109	831031	-9.0000	-9.000	-9.000	-9.000	-9.000	3.0	57.4	157.9	10.0	2.5	48.2	12.1	10.0	339	292.1	8.22	8.10	245
110A	M110	831101	0.0045	-9.000	-9.000	-9.000	-9.000	3.7	50.6	160.0	10.4	4.2	46.4	12.0	10.0	346	288.2	8.35	8.30	250
110A	M112	831101	0.0003	-9.000	-9.000	-9.000	-9.000	3.0	53.4	152.3	9.7	2.2	45.8	11.8	9.0	354	279.2	7.91	8.00	250
110A	M114	831101	0.0003	-9.000	-9.000	-9.000	-9.000	3.4	54.4	155.5	10.1	2.8	44.8	12.8	11.0	372	284.8	8.22	8.30	275
110A	M116	831101	0.0003	0.005	0.016	0.000	-9.000	3.3	61.0	156.4	9.9	2.5	47.6	12.2	9.0	382	293.9	7.95	8.10	270
110A	476	831130	0.0014	0.025	0.422	0.025	-9.000	3.3	46.8	170.0	10.2	2.4	46.6	12.2	6.0	360	292.5	7.67	8.20	235
110A	722	840320	0.0000	0.000	0.000	0.000	-9.000	3.0	49.8	174.6	9.6	2.5	49.5	12.3	12.0	-9	303.6	7.56	8.10	210
110A	916	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	3.4	59.0	174.4	10.5	2.7	52.5	13.3	14.0	-9	317.8	6.62	7.90	270
110B	M118	831101	0.0072	0.005	0.494	0.000	-9.000	2.9	38.3	178.2	9.7	2.1	46.1	13.3	10.0	332	291.6	8.23	8.20	240
110B	MP82	831104	0.0150	0.034	0.287	0.012	-9.000	2.8	40.2	177.8	9.6	2.4	46.0	12.4	10.0	353	292.2	8.25	8.10	255
110B	MP84	831104	-9.0000	-9.000	-9.000	-9.000	-9.000	2.8	40.6	178.6	9.6	2.4	46.4	12.2	9.5	336	293.6	8.30	8.20	240
110B	MP86	831104	0.0170	0.015	0.294	0.012	-9.000	2.8	38.0	175.9	9.6	2.4	46.4	12.3	9.5	329	288.4	8.35	8.30	235
110B	444	831128	0.0100	0.025	0.980	0.025	-9.000	3.0	33.5	194.5	10.3	2.7	47.4	12.2	5.0	291	304.6	7.66	8.20	185
110B	724	840320	0.0000	0.000	0.000	0.058	-9.000	2.5	24.8	128.8	6.6	2.5	32.8	8.5	13.0	-9	208.8	7.61	7.90	225
110B	920	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	3.2	46.9	174.8	10.1	2.7	48.9	12.3	12.5	-9	300.9	6.78	7.90	280
111A	M94	831028	0.0025	-9.000	0.073	0.000	-9.000	1.7	12.9	160.9	5.5	1.6	35.5	12.1	8.5	272	231.2	7.23	8.10	190
111A	M96	831028	0.0025	0.040	0.000	0.000	-9.000	1.4	10.8	156.9	5.2	1.3	34.2	11.8	9.0	261	222.6	8.17	7.90	185
111A	M98	831028	0.0025	-9.000	-9.000	-9.000	-9.000	3.0	52.6	166.9	9.3	1.8	47.8	13.9	10.0	353	296.3	8.04	8.10	255
111A	M100	831028	0.0025	-9.000	-9.000	-9.000	-9.000	2.9	43.8	165.9	9.1	1.6	44.8	13.8	12.0	310	282.9	7.23	8.10	235
111A	M102	831028	0.0025	0.005	0.045	0.000	-9.000	1.7	19.6	148.7	8.9	1.2	33.3	12.3	10.0	297	226.7	7.26	7.90	215
111A	440	831128	0.0007	0.150	0.000	0.025	-9.000	5.5	31.7	156.9	20.7	3.4	33.1	10.5	6.5	324	262.8	8.08	8.10	215
111A	726	840321	0.0000	0.000	0.000	0.000	-9.000	1.5	10.6	163.3	5.3	1.2	34.8	12.0	7.0	-9	231.0	8.01	7.80	190
111A	912	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.7	9.2	137.2	5.0	1.1	29.2	9.9	8.0	-9	195.3	6.64	7.80	160
111B	442	831128	0.0007	0.025	0.000	0.025	-9.000	5.1	11.1	160.9	5.1	1.2	33.0	12.3	5.5	271	226.1	7.45	8.20	175
111B	730	840321	0.0000	0.000	0.000	0.000	-9.000	1.3	10.9	153.7	4.9	0.9	33.7	11.7	7.0	-9	219.4	7.54	7.70	185
111B	914	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.6	8.3	132.8	4.8	1.0	27.8	9.8	6.0	-9	188.1	6.60	7.90	155
113	278	830922	0.3970	3.800	9.098	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	522	-9.0	-9.00	-9.00	395
113	314	831007	0.2680	1.200	6.894	0.012	-9.000	3.7	16.8	311.9	10.1	4.6	69.5	18.6	13.5	459	436.8	7.31	7.90	360

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
113	377	831020	0.4310	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	472	-9.0	7.05	-9.00	345
114	280	830922	0.0813	1.200	5.998	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	396	-9.0	6.33	-9.00	280
114	316	831007	0.1040	2.600	4.694	0.012	-9.000	3.5	18.0	216.1	10.2	3.5	55.2	8.9	11.5	381	317.0	7.03	7.70	285
114	378	831020	0.0780	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	318	-9.0	7.15	-9.00	230
115	288	830922	0.0564	14.000	9.998	0.012	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.5	816	-9.0	5.42	-9.00	625
115	318	831007	0.0290	19.000	9.794	0.012	-9.000	7.3	5.4	496.9	18.6	4.9	116.6	20.4	14.0	756	671.7	7.02	7.40	600
115	381	831020	0.0340	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	383	-9.0	7.10	-9.00	265
115	427	831118	0.0380	8.300	7.786	0.041	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.5	718	-9.0	7.05	-9.00	550
116	286	830922	0.1530	10.000	3.998	0.044	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	12.0	462	-9.0	5.10	-9.00	350
116	320	831007	0.1340	11.000	3.594	0.032	-9.000	1.8	1.0	292.8	5.0	3.6	64.0	14.8	12.5	463	385.0	7.11	7.40	355
116	428	831118	0.1010	3.800	3.386	0.160	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	547	-9.0	7.92	-9.00	400
117	415	831116	0.0190	12.000	8.286	0.213	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	1102	-9.0	7.22	-9.00	750
118A	402	831114	0.1100	4.100	3.786	0.090	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	411	-9.0	7.55	-9.00	280
118B	403	831114	0.2560	14.000	3.586	0.500	0.123	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	566	-9.0	7.90	-9.00	375
119A	404	831116	0.3220	18.000	5.786	2.300	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	730	-9.0	7.08	-9.00	470
119B	405	831116	5.1000	23.000	3.186	0.700	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	1273	-9.0	7.08	-9.00	820
120	401	831114	0.0320	3.300	8.586	1.300	0.060	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	1331	-9.0	-9.00	-9.00	920
121A	406	831116	0.2140	22.000	6.086	0.173	0.000	3.8	0.5	652.6	14.3	6.2	134.0	37.7	6.0	1072	849.6	6.79	7.80	700
121A	569	840127	0.2600	32.930	7.900	0.100	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.0	-9	-9.0	6.89	-9.00	625
121A	593	840223	0.2200	30.930	7.970	0.013	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	-9	-9.0	6.82	-9.00	440
121A	746	840321	0.1600	34.960	8.300	0.000	-9.000	3.1	0.5	704.3	12.7	5.4	123.0	37.1	6.5	-9	889.4	6.19	7.40	825
121A	788	840427	0.2700	34.000	8.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.0	-9	-9.0	6.89	-9.00	700
121A	873	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	6.90	-9.00	415
121A	936	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	3.3	0.5	705.3	13.2	6.6	144.0	37.9	8.0	-9	912.3	6.31	7.20	850
121B	408	831116	0.0240	14.000	8.786	0.141	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	4.0	630	-9.0	6.85	-9.00	390
121B	594	840224	0.0200	16.930	8.770	0.120	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	-9	-9.0	6.97	-9.00	450
121B	748	840321	0.0190	19.960	9.000	0.000	-9.000	2.1	102.0	238.2	6.7	2.8	87.0	17.8	4.5	-9	457.7	6.41	7.10	550
122A	412	831116	3.7000	22.000	4.886	0.432	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	1401	-9.0	7.00	-9.00	940
122A	567	840127	6.2000	55.930	5.500	0.400	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.8	6.0	-9	-9.0	6.94	-9.00	950
122A	591	840224	7.0000	59.930	5.470	0.430	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	-9	-9.0	7.14	-9.00	850
122A	742	840321	7.3000	63.960	5.800	0.411	-9.000	3.5	0.5	931.1	17.7	8.4	152.0	51.3	6.5	-9	1170.8	6.02	7.00	1050
122A	786	840427	6.6000	61.000	5.500	0.388	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	-9	-9.0	6.73	-9.00	1000
122A	871	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	6.76	-9.00	750
122A	932	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	3.6	0.5	916.0	17.4	9.3	147.0	49.5	9.5	-9	1144.8	6.20	7.20	1050
122B	411	831116	0.0100	28.000	2.786	0.161	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	1654	-9.0	7.02	-9.00	1110
122B	568	840127	0.0890	28.930	13.000	0.046	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	2.0	-9	-9.0	6.84	-9.00	900
122B	592	840224	0.2100	58.930	12.970	0.021	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	3.0	-9	-9.0	7.63	-9.00	1050
122B	744	840321	0.0940	59.960	13.000	0.000	-9.000	2.4	432.0	926.6	13.2	5.9	228.0	51.7	4.5	-9	1663.2	6.16	7.00	1250
122B	787	840427	0.1000	59.000	12.000	0.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	-9	-9.0	6.88	-9.00	1300
122B	872	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.0	-9	-9.0	6.86	-9.00	980
122B	934	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	2.4	517.0	681.2	18.1	8.4	308.0	64.2	14.0	-9	1601.3	6.26	7.30	1700
123A	418	831117	5.5000	20.000	3.286	0.365	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	1192	-9.0	7.10	-9.00	800
123A	565	840127	8.5000	37.930	3.000	0.370	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.5	-9	-9.0	7.02	-9.00	800
123A	589	840223	9.5000	40.930	1.970	0.350	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	-9	-9.0	7.13	-9.00	750
123A	738	840321	10.0000	45.960	3.100	0.351	-9.000	2.4	0.5	774.6	14.0	6.7	115.0	43.0	7.0	-9	961.8	6.86	7.30	900
123A	784	840427	9.3000	44.000	2.900	0.348	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.0	-9	-9.0	6.92	-9.00	900
123A	869	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	-9	-9.0	6.91	0.00	350
123A	928	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.8	0.5	746.0	14.6	9.0	123.0	41.4	8.0	-9	937.8	6.40	7.40	850
123B	429	831118	2.2000	41.000	3.686	0.900	0.036	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	9.5	1260	-9.0	6.46	-9.00	900

Well	Samp	Date	As	Fe	Mn	Zn	Cu	Cl	SO4	HCO3	Na	K	Ca	Mg	Temp	SPC25	TDS	FpH	LpH	FSPC
123B	566	840127	3.4000	44.930	3.300	0.360	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.0	-9	-9.0	7.18	-9.00	750
123B	590	840223	4.7000	52.930	2.970	0.360	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.0	-9	-9.0	7.13	-9.00	800
123B	740	840321	4.9000	55.960	3.200	0.361	-9.000	1.4	0.5	770.0	12.2	7.2	139.0	46.3	5.5	-9	979.6	6.19	7.00	900
123B	7B5	840427	4.5000	55.000	3.100	0.348	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.0	-9	-9.0	6.89	-9.00	850
123B	870	840531	-9.0000	-9.000	-9.000	-9.000	-9.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	11.0	-9	-9.0	6.89	-9.00	380
123B	930	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.4	0.5	773.3	12.1	8.3	142.5	44.9	8.0	-9	984.5	6.51	7.10	900
123C	430	831118	0.0220	7.800	7.386	0.900	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	10.5	958	-9.0	7.66	-9.00	700
124	417	831117	0.0050	4.000	11.986	1.300	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	1009	-9.0	7.34	-9.00	650
125	416	831117	0.0310	2.500	7.986	0.600	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	5.5	473	-9.0	7.32	-9.00	305
126	414	831116	0.1060	0.300	5.686	6.800	0.018	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	831	-9.0	7.42	-9.00	550
127	413	831116	0.0110	4.100	17.986	1.400	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	8.0	1592	-9.0	6.95	-9.00	1100
128	410	831116	0.0260	6.200	5.886	2.500	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	6.5	1632	-9.0	7.23	-9.00	1080
129	419	831118	0.4460	0.021	1.786	0.079	0.018	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	19.0	1071	-9.0	7.84	-9.00	950
130	420	831118	0.0150	2.000	16.986	0.407	0.005	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	798	-9.0	6.22	-9.00	650
131	421	831118	0.0200	1.150	24.986	13.000	0.012	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	15.0	1106	-9.0	6.79	-9.00	900
136	409	831116	0.0400	6.700	4.186	0.039	0.000	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	-9.0	7.0	581	-9.0	7.33	-9.00	390
BLK	244	830901	0.0007	0.017	0.013	0.011	0.000	0.4	5.4	159.8	4.3	0.9	30.9	11.5	21.0	243	213.2	8.41	8.30	225
BLK	772	840323	0.0000	0.000	0.000	0.000	-9.000	1.0	7.4	150.9	4.3	1.4	31.0	10.7	7.0	-9	207.8	8.28	8.20	170
BLK	954	840627	-9.0000	-9.000	-9.000	-9.000	-9.000	0.3	2.6	106.4	2.0	0.7	22.1	7.7	18.0	-9	143.8	8.38	8.20	168
CLK	242	830901	0.0063	0.005	0.008	0.000	0.005	3.4	51.6	161.9	10.5	2.8	45.9	12.2	20.0	353	288.8	8.65	8.50	320
CLK	766	840323	0.0000	0.000	0.100	0.000	-9.000	3.3	53.0	152.0	9.6	2.5	44.4	12.3	6.5	-9	278.2	8.10	7.90	240
CLK	922	840626	-9.0000	-9.000	-9.000	-9.000	-9.000	1.6	19.1	94.8	5.2	1.8	24.3	6.3	16.0	-9	155.1	7.16	8.00	175

TABLES OF SPECIALTY CHEMISTRY

PEARSON CORRELATIONS

AND
SURFACE SOIL SAMPLING CHEMISTRY

Table 1 : Analyses for Fluoride, Nitrate and Antimony at Selected Wells.

Well#	Concentration in mg/l		
	Fluoride* 1-24-84	Nitrate** 1-31-84	Antimony *** 3-10-84
2	0.47		
6	0.36	0.68	-0.002 @
7	0.40		
8			-0.002
9	0.56	0.03	0.002
10	0.82		-0.002
17	0.26		
19		0.21	
35	0.06		
36	0.09		
D	0.24		
G		0.05	
C-2	0.10	0.18	
99	0.50	0.34	
100A	0.20		
100B	0.55	0.03	
101A	4.5		
101B	0.45	0.03	0.005
102A	0.69		
102B	0.64	0.03	0.007
103A	3.6		
103B	0.57		-0.002
104B	0.55	0.19	
105A	0.48		
105B	0.32	0.35	
105C	0.32		
106A		0.21	
106B	0.14		
106C	0.13	0.15	
107A	0.48		0.002
107B	8.5		
107C	0.37		0.011
108A	0.22		
108B	0.14		
109A	0.09		
109B	0.08	0.03	
110A	0.48		
110B	0.44		
111A	0.28		
111B	0.12		
116A			-0.002
116B			-0.002
118A			-0.002
119A			0.002
121A	0.29		-0.002
121B			-0.002
122A			0.006
122B			-0.002
123A			0.014
123B			0.006
Blank			-0.002

* analysis by electrode, ** analysis by STO Methods, ***hydride generation USGS Denver
@ minussign indicates below detection

Table: 2: Mercury and Selenium Data*

Well #	Mercury (mg/l)	Selenium (mg/l)
6	-0.001	-0.005
8	-0.001	-0.005
9	-0.001	-0.005
10	-0.001	-0.005
11	-0.001	-0.005
17	-0.001	-0.005
C-2	-0.001	-0.005
D	-0.001	-0.005
G	-0.001	-0.005
H	-0.001	-0.005
101B	-0.001	-0.005
102B	-0.001	-0.005
106B	-0.001	-0.005
109B	-0.001	-0.005
113	-0.001	-0.005
BLANK	-0.001	-0.005

- less than

* analysis completed by Northern Engineering and Testing Inc.
Mercury- Cold Vapor: EPA-600/4-79-020 method 245.1
Selenium- AA Furnace: EPA-600/4-79-020 method 270.2
AA Hydride: EPA-600/4-79-020 method 270.3

Table 3 : Tannin and Lignin-like substances, sampling 6-23-75, 10-18-82, 8-30-83 and 2-22-84.

Well #	Concentration (mg/l) 6/75+	 10/82	 8/83	 2/84 ***
2	1.3		0.1	
3			0.2	
6		1.2	1.1	0.1
7		0.16	0.1	
8		0.45	0.5	
9		1.74	0.9	0.2
10		-0.05*	0.2	
11			-0.1	
17			-0.1	
18			0.6 0.3	
19	-0.1.		-0.1	
B		-.05		-.01
C-2			0.1	-.01
C-3			0.1	
C-4			-0.1	
C-8			-0.1	
C-21			-0.1	
D			0.1	
E			0.1	

Well #	Concentration (mg/l) 6/75	 10/82	 8/83	 2/84 ***
F			0.1	
G	5.5	1.31	1.2	0.1
H		-0.05	0.1	
H-8			0.1	
J	4.0		0.6	
L			0.1	
M-16			-0.1	
M-17			0.2	
20			-0.1	
23			-0.1	
28			-0.1	
30			0.2	
99				-0.1
101B			1.2	0.2
102B				0.2
104B				0.1
105B				-0.1
106A				-0.1
106C				-0.1

Well #	Concentration (mg/l) 6/75	 10/82	 8/83	 2/84 ***
109B				-0.1
121A				0.2
122A				0.4
123B				0.2
Mill Pond 8/75	35.0 295			
Blackfoot River			0.2	
Clark Fork River			-0.1	
Blank			-0.1	
STD **			9.2	

*minus sign = below detection ** Standard was tannic acid 10.0 mg/l *** 92%recovery on lab spike

+ 1975 report by DHES

Table 4 : Total Organic Carbon*

Well#	Concentration in mg/l
6	3.6
9	8.8
19	1.2
G	26.6
C-2	2.8
99A	0.0
99B	2.2
101A	6.2
101B	10.9
102B	9.4
105B	0.6
106A	0.9
106C	0.3
109B	0.0
121A	15.6
122A	27.6
122B	29.6
123A	43.6
123B	25.6

*Analysis by Rocky Mountain Lab, Denver using oxidation-infrared adsorption EPA method #410.4

Table 5 : Arsenic Speciation Results for Seclected Groundwater Samples, April 27, 1984 to May 4, 1984.*

Well #	Arsenic Concentration (mg/l)				
	Total As	AsIII	AsV	AsIII/AsTotal	AsV/AsTotal
6	0.410	0.340	0.076	83%	18%
8	0.320	0.200	0.120	62%	38%
9	0.650	0.580	0.130	89%	20%
9 duplicate	0.650	0.610	0.110	94%	17%
10	0.250	0.000	0.210	0%	93%
101B	0.810	0.820	0.110	101%	14%
102B	0.880	0.710	0.130	81%	15%
103B	0.053	0.000	0.050	0%	94%
107C	0.910	0.760	0.230	84%	25%
107A	0.200	0.100	0.100	50%	50%
118A	0.500	0.350	0.180	70%	36%
119B	4.700	4.300	0.480	92%	10%
119A	0.540	0.320	0.190	59%	35%
116	0.130	0.150	0.000	115%	0%
121A	0.210	0.210	0.000	100%	0%
1228	0.090	0.100	0.000	111%	0%
122A	4.300	4.200	0.100	98%	2%
123B	4.100	2.500	0.000	61%	0%
123A	9.800	6.900	2.600	70%	26%
Blank	0.000	0.000	0.000		

* Analyses performed by Walter Ficklin, USGS, Denver, Co. Results are "working results" only and are being refined.

Samples submitted 3-10-84 were run for dimethylarsenite, no trace was found

Table 6 : Tritium Data, July, 1983.

Well #	Tritium Units
6	55
8	66
10	56
11	52
18	45
C-2	41
D	54
Clark Fork River	46

Table 7: Arsenic, Manganese and TDS with Depth Below Water Table (Nov 1983-Mar 1984)

	99A	99B	101B		102B		103B		104B		105B		106A	
Depth	55	19	2.1	6.2	13.2	16.5	16.4	19.2	23.6	28.3	36.7	41.5	81.5	86.4
As	.000	.000	0.634	0.861	0.621	0.771	0.024	0.000	0.016	0.000	0.001	0.000	0.001	0.000
Mn	.000	.000	8.780	9.490	5.880	5.990	2.280	2.090	3.080	3.490	0.000	0.000	0.280	0.040
TDS	199	199	530	565	417	355	274	262	453	418	205	202	---	151

	106C		107A		107C		108B		109B		110B		111A	
Depth	31.6	36.4	34.0	38.8	12.1	17.0	10.8	15.3	52.7	64.3	30.6	33.6	90.1	95.1
As	0.001	0.000	0.211	0.054	0.023	0.361	0.001	0.000	0.001	0.000	0.010	0.000	0.001	0.000
Mn	0.000	0.000	4.780	3.290	2.280	4.890	0.000	0.000	0.580	0.040	0.980	0.000	0.000	0.000
TDS	170	158	486	402	401	519	174	168	164	161	195	129	157	163

	111B		121A		121B		122A		122B		123A		123B	
Depth	37.0	42.0	0.1	4.7	3.0	4.1	3.8	6.3	2.7	3.3	0.1	3.5	4.3	5.5
As	0.001	0.000	0.214	0.160	0.024	0.019	3.700	7.300	0.010	0.094	5.500	10.00	2.200	4.900
Mn	0.000	0.000	6.086	8.300	8.786	9.000	4.886	5.800	2.786	13.00	3.286	3.100	3.686	3.200
TDS	161	154	653	704	---	238	---	931	---	927	---	775	---	770

Table 8a: Pearson Correlations: Areawide 1983 $p < 0.10$

			Aug-Sept		Nov-Dec	
			r	n	r	n
As	with	Fe	.870	45	.845	38
		Mn	.843	44	.788	38
		Na				
		K	.757	43		
		Ca	.646	43	.562	37
		Mg	.608	43		
		HCO_3	.748	43		
		Cl				
		SO_4				
Fe	with	Mn	.762	44	.795	38
		Na				
		K				
		Ca	.617	43		
		Mg	.580	43		
		HCO_3	.710	43		
		Cl				
		SO_4				
Mn	with	Na				
		K	.770	43		
		Ca	.779	43	.827	37
		Mg	.751	43	.709	37
		HCO_3	.833	43	.656	37
		Cl	.610	43		
		SO_4				
Na	with	K			.873	37
		HCO_3			.731	37
		Cl			.923	37
		SO_4			.910	37
K	with	HCO_3	.763	43	.884	37
		Cl	.555	43	.780	37
		SO_4			.703	37
Ca	with	Mg	.960	43	.813	37
		HCO_3	.789	43	.618	37
		Cl	.596	43		
		SO_4				
Mg	with	HCO_3	.759	43	.760	37
		Cl	.576	43		
		SO_4				

Table 8b: Pearson Correlations: Areawide 1983 $p < 0.10$

			Aug-Sept		Nov-Dec	
			r	n	r	n
HCO_3	with	Cl	.804	43	.759	37
		SO_4			.594	37
Cl	with	SO_4			.950	37
pH	with	As				
		Fe				
		Mn				
		Na				
		K				
		Ca				
		Mg				
		HCO_3				
		Cl				
		SO_4			.605	37
SPC	with	As	.609	41		
		Fe				
		Mn	.594	40		
		Na			.840	37
		K	.612	40	.883	37
		Ca	.606	40		
		Mg			.722	37
		HCO_3	.732	40	.922	37
		Cl	.685	40	.888	37
		SO_4			.803	37
TDS	with	As	.687	43		
		Fe	.654	43		
		Mn	.782	43		
		Na			.902	37
		K	.751	43	.908	37
		Ca	.787	43		
		Mg	.720	43	.639	37
		HCO_3	.979	43	.937	37
		Cl	.822	43	.929	37
		SO_4			.834	37
pH	with	SPC				
		TDS				
SPC	with	TDS	.777	40	.967	37

Table 8c: Pearson Correlations: Areawide 1983 $p < 0.10$

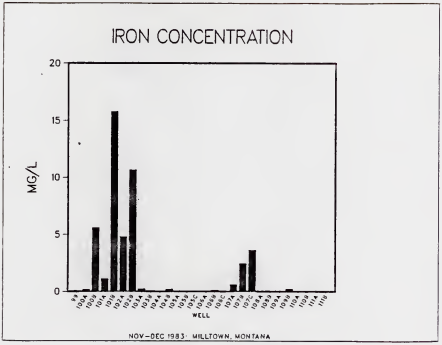
		Aug-Sept		Nov-Dec	
		r	n	r	n
Level with	As				
	Fe				
	Mn	.717	5		
	Na				
	K	.804	4		
	Ca	.944	4		
	Mg	.926	4		
	HCO_3	.890	4		
	Cl				
	SO_4				
CFQ with	As				
	Fe	.586	45		
	Mn				
	Na				
	K				
	Ca				
	Mg				
	HCO_3				
	Cl	.578	43		
	SO_4				

Table 9: Results of Surface Soil Sampling.

Sample	Location	ug As/g soil
S1	Adjacent to Well 109 drilling site	1.15
S2	Near Well 108 drilling site; near well C-8	0.11
S3	Leo Gonsoir's garden	7.19
S4	Near well site 104	0.16
S5	Champion International log deck - southeast side	9.06
S6	" " " " Behind Gonsoir's	19.2
S7	" " " " 20 yds. from MPC gas hut	13.3
S8	Champion deck office - near well site 111	2.13
S9	Deb Anderson's garden	0.16
S10	Garden adjacent to Anderson's	2.46
S11	Lawn of brick house on corner of 1st St. and freeway	1.5, 1.4
S12	Van Holt's yard - northeast corner of lawn	1.13
S13	Schmidt's garden	2.08
S14	Near well site 107; southeast side of pumphouse	1.97
S15	Melody Fuch's lawn	23.6
S16	Grassy area across from 4th St.	1.11, 0.17
S17	Corner house on northwest side of 5th St.	0.1
S18	Field west of well site 103	0.11
S19	Well site 103	0.05
S20	Field, east of well site 103	0.11
S21	Between RR tracks and road; west of well 11	0.23
S22	107 S. 1st St. (south side of front yard)	0.13
S23	Well site 105	0.19
S24	Well site 106	0.05
S25	Between well sites 110A & 110B	0.27
S26	Lawn between Bonner School and St. Ann's Church	0.49
S27	Well 11 site, front yard	1.21
S28	South of RR tracks, east of well 10	1.83
S29	Well 17 site - backyard	0.29
S30	206 N. 1st St., front lawn	0.21
S31	South side of Well C-2	0.45
S32	Hunter's garden: 950 2nd St., West Riverside	0.19
S33	Woessner's garden: 126 E. McCleod, Missoula	0.17
S34	Moore's garden: 1763 S. 9th W., Missoula	0.12, 0.16
S35	Field, east are of Reservoir	8.44
S36	Field, east area of Reservoir	13.2
S37	Near base of old dump	9.8
S38	Field site in Reservoir	10.9
S39	Marsh site in Reservoir	11.3
S40	Field	14.9
S41	Marsh	10.3
S42	Amidst cattails - west end of Reservoir	13.3, 11.5
S43	Marsh	9.99
S44	Marsh	6.25
S45	Field	8.6
S46	Field - between I90 and first slough	3.6
S47	Marsh - east end of Reservoir by Deer Creek	9.7
S48	Marsh - east end of Reservoir by Deer Creek	9.95
S49	Small island, east end of Reservoir	10.1
S50	Island, east end	8.1, 12
S51	Island, west end	8.85
S52	South bank of Reservoir	7.1
S53	South bank of Reservoir	6.9

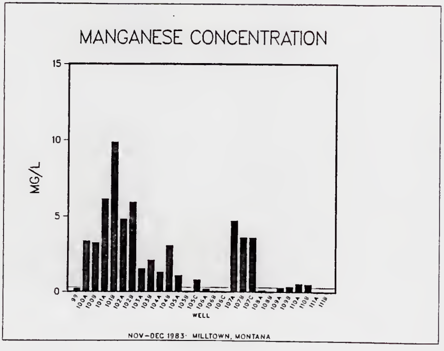
BAR GRAPHS OF HEAVY METAL CONCENTRATIONS
AND CHEMISTRY FOR SELECTED
COMMUNITY AND PROJECT WELLS, AND SANDPOINTS

(NOV-DEC 1983 AND MARCH 1984)



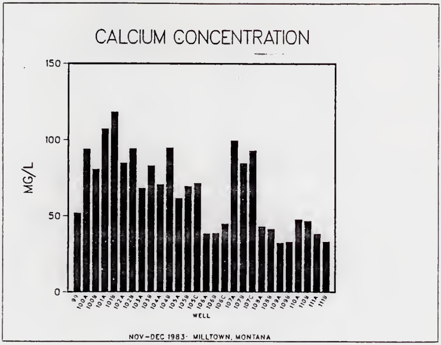
IRON CONCENTRATION

NOV–DEC 1983· MILLTOWN, MONTANA



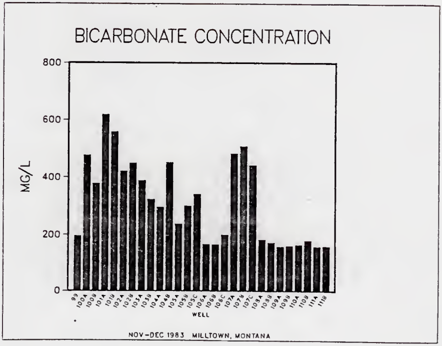
MANGANESE CONCENTRATION

NOV–DEC 1983· MILLTOWN, MONTANA



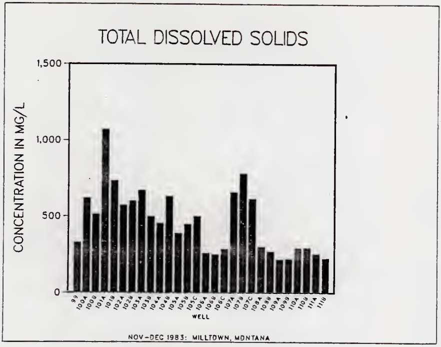
CALCIUM CONCENTRATION

NOV-DEC 1983 MILLTOWN, MONTANA



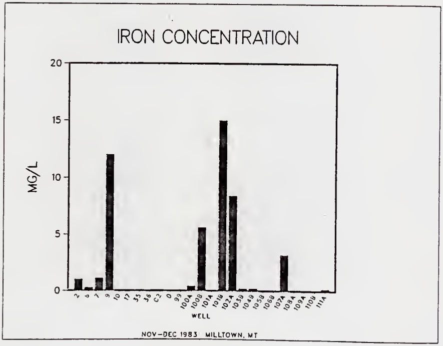
BICARBONATE CONCENTRATION

NOV-DEC 1983 MILLTOWN, MONTANA



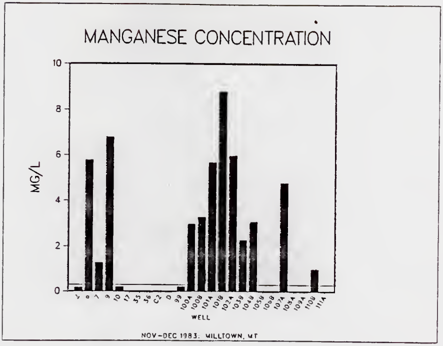
TOTAL DISSOLVED SOLIDS

NOV-DEC 1983: MILLTOWN, MONTANA



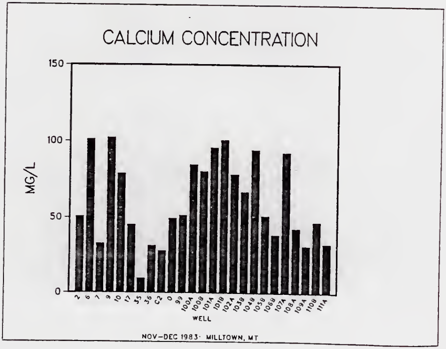
IRON CONCENTRATION

NOV-DEC 1983 MILLTOWN, MT



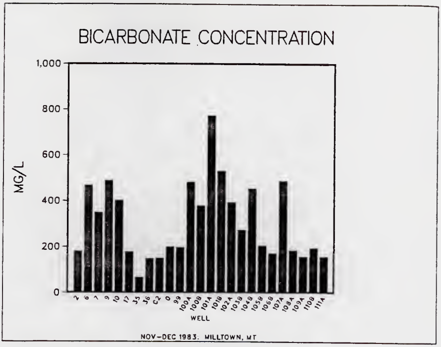
MANGANESE CONCENTRATION

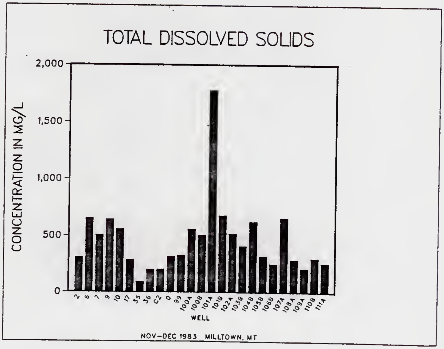
NOV-DEC 1983: MILLTOWN, MT

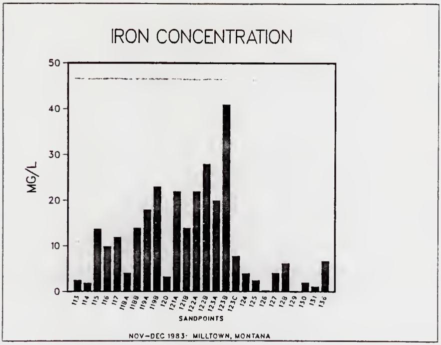


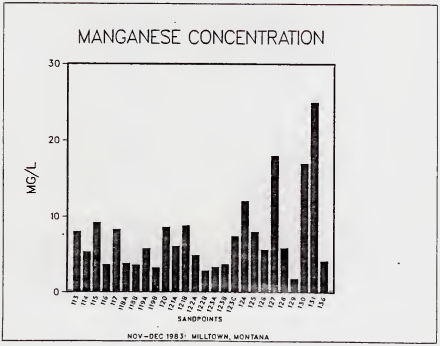
CALCIUM CONCENTRATION

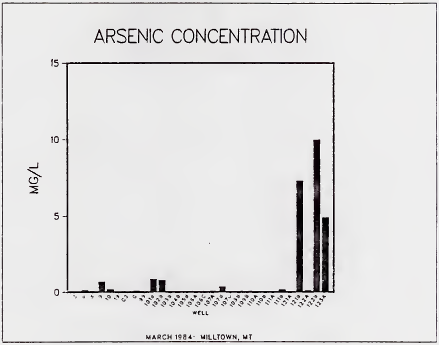
NOV-DEC 1983· MILLTOWN, MT


BICARBONATE CONCENTRATION
MG/L
1,000
800
600
400
200
0
2
6
7
9
10
17
35
36
C2
O
99
100A
100B
101A
101B
102A
103B
104B
105B
106B
107A
108A
109A
110B
111A
WELL
NOV-DEC 1983: MILLTOWN, MT

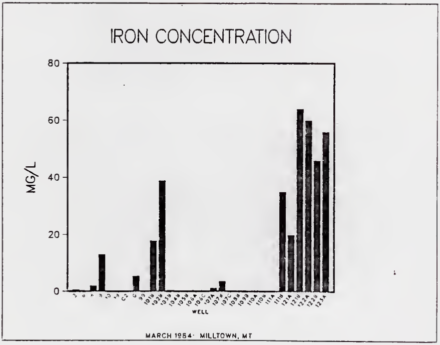

TOTAL DISSOLVED SOLIDS
CONCENTRATION IN MG/L
2,000
1,500
1,000
500
0
2
6
7
9
10
17
35
36
C2
O
99
100A
100B
101A
101B
102A
103B
104B
105B
106B
107A
108A
109A
110B
111A
WELL
NOV-DEC 1983 MILLTOWN, MT


IRON CONCENTRATION
MG/L
0
10
20
30
40
50
113
114
115
116
117
118A
118B
119A
119B
120
121A
121B
122A
122B
123A
123B
123C
124
125
126
127
128
129
130
131
136
SANDPOINTS
NOV–DEC 1983· MILLTOWN, MONTANA

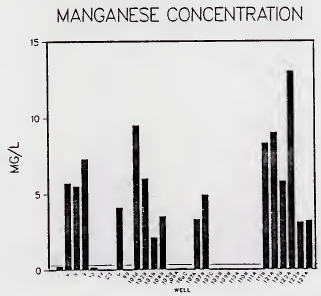

MANGANESE CONCENTRATION
MG/L
0
10
20
30
113
114
115
116
117
118A
118B
119A
119B
120
121A
121B
122A
122B
123A
123B
123C
124
125
126
127
128
129
130
131
136
SANDPOINTS
NOV–DEC 1983· MILLTOWN, MONTANA



MARCH 1984· MILLTOWN, MT



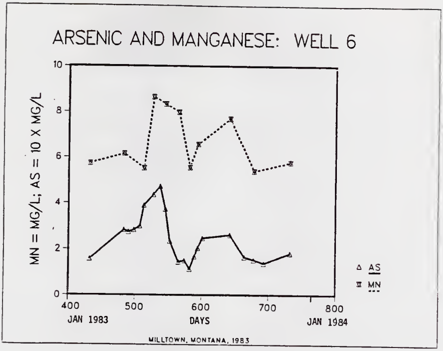
MARCH 1984· MILLTOWN, MT

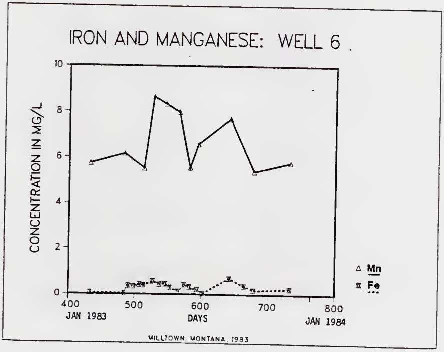


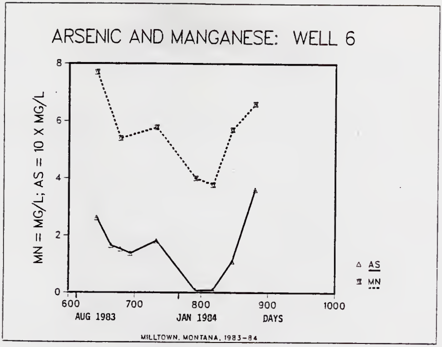
MARCH 1984 · MILLTOWN, MT

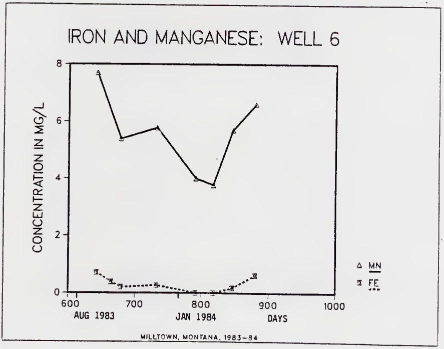
GRAPHS OF As vs. Mn AND Mn vs. Fe
FOR WELLS 6, 9, C-2, G, 99A, 101B, 109B,
AND SANDPOINT 121A

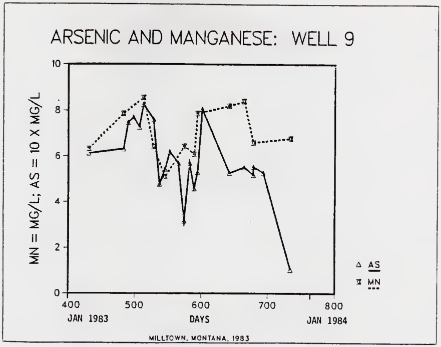
(DAYS SCALE BEGINS NOVEMBER 26, 1981)

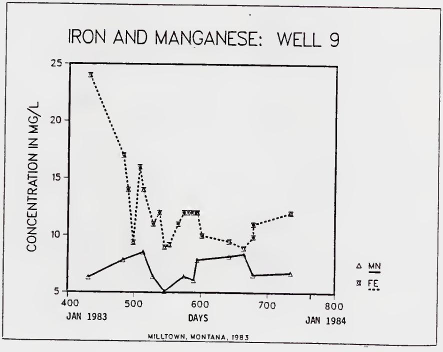

ARSENIC AND MANGANESE: WELL 6
MN = MG/L; AS = 10 X MG/L
0
2
4
6
8
10
400
JAN 1983
500
600
DAYS
700
800
JAN 1984
AS
MN
MILLTOWN, MONTANA, 1983

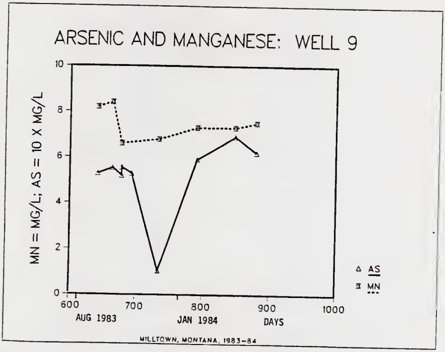

IRON AND MANGANESE: WELL 6
CONCENTRATION IN MG/L
0
2
4
6
8
10
400
JAN 1983
500
600
DAYS
700
800
JAN 1984
Mn
Fe
MILLTOWN, MONTANA, 1983

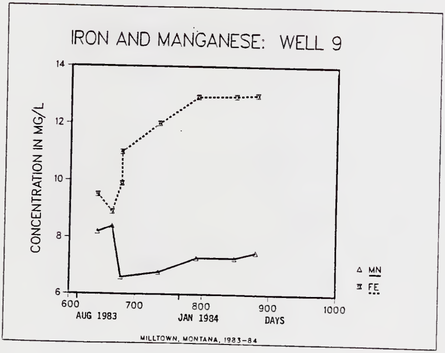

ARSENIC AND MANGANESE: WELL 6
MN = MG/L; AS = 10 X MG/L
8
6
4
2
0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ AS
⧗ MN
MILLTOWN, MONTANA, 1983-84

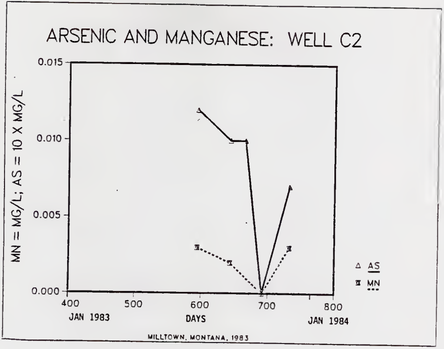

IRON AND MANGANESE: WELL 6
CONCENTRATION IN MG/L
8
6
4
2
0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ MN
⧗ FE
MILLTOWN, MONTANA, 1983-84

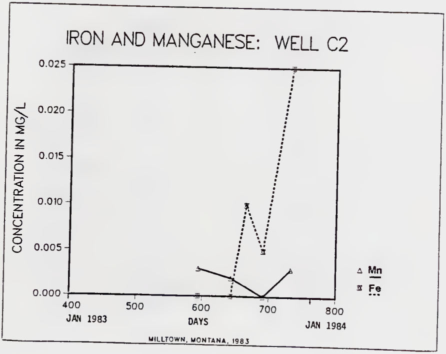

ARSENIC AND MANGANESE: WELL 9
MN = MG/L; AS = 10 X MG/L
10
8
6
4
2
0
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
△ AS
⌧ MN
MILLTOWN, MONTANA, 1983

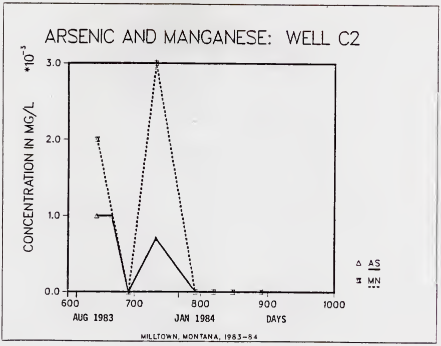

IRON AND MANGANESE: WELL 9
CONCENTRATION IN MG/L
25
20
15
10
5
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
△ MN
⌧ FE
MILLTOWN, MONTANA, 1983

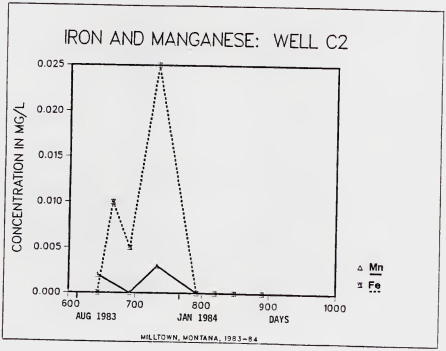

ARSENIC AND MANGANESE: WELL 9
MN = MG/L; AS = 10 X MG/L
10
8
6
4
2
0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
Δ AS
MN
MILLTOWN, MONTANA, 1983-84

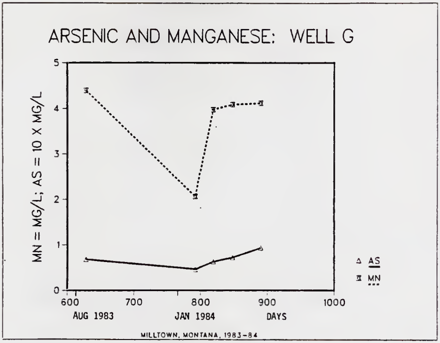

IRON AND MANGANESE: WELL 9
CONCENTRATION IN MG/L
14
12
10
8
6
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
Δ MN
FE
MILLTOWN, MONTANA, 1983-84

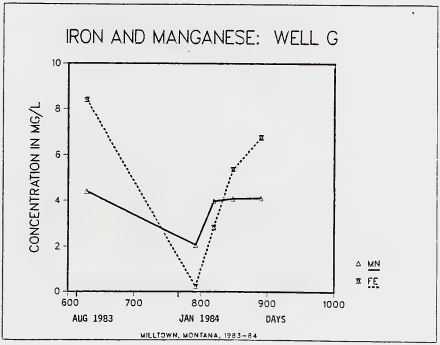

ARSENIC AND MANGANESE: WELL C2
MN = MG/L; AS = 10 X MG/L
0.015
0.010
0.005
0.000
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
AS
MN
MILLTOWN, MONTANA, 1983

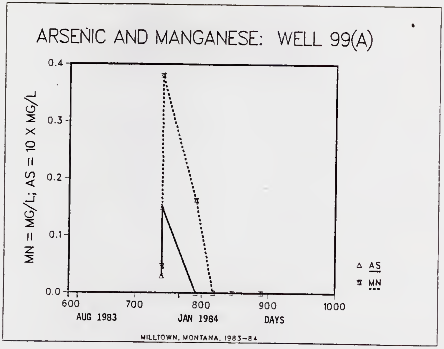

IRON AND MANGANESE: WELL C2
CONCENTRATION IN MG/L
0.025
0.020
0.015
0.010
0.005
0.000
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
Mn
Fe
MILLTOWN, MONTANA, 1983

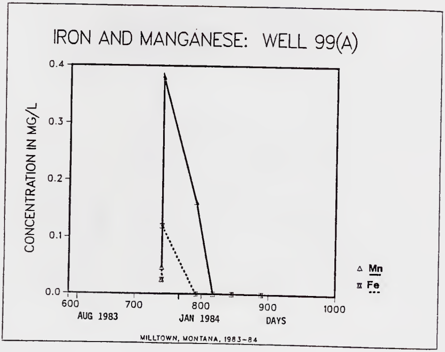

ARSENIC AND MANGANESE: WELL C2
CONCENTRATION IN MG/L *10⁻³
3.0
2.0
1.0
0.0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ AS
⌛ MN
MILLTOWN, MONTANA, 1983-84

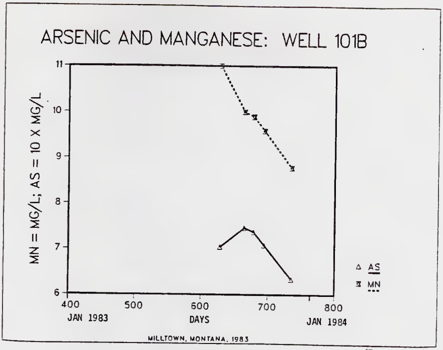

IRON AND MANGANESE: WELL C2
CONCENTRATION IN MG/L
0.025
0.020
0.015
0.010
0.005
0.000
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ Mn
⌛ Fe
MILLTOWN, MONTANA, 1983-84

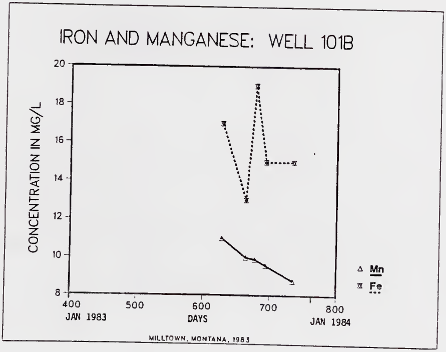

ARSENIC AND MANGANESE: WELL G
MN = MG/L; AS = 10 X MG/L
0
1
2
3
4
5
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
AS
MN
MILLTOWN, MONTANA, 1983-84

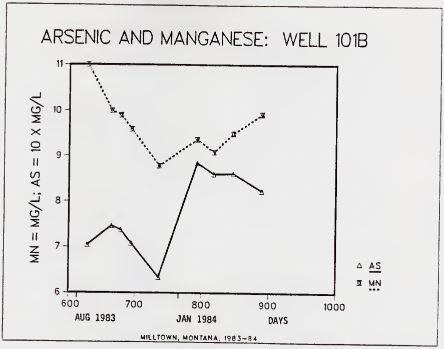

IRON AND MANGANESE: WELL G
CONCENTRATION IN MG/L
0
2
4
6
8
10
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
MN
FE
MILLTOWN, MONTANA, 1983-84

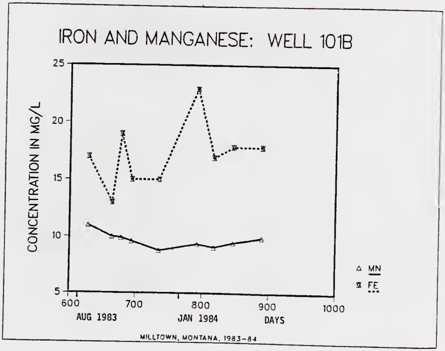

ARSENIC AND MANGANESE: WELL 99(A)
MN = MG/L; AS = 10 X MG/L
0.4
0.3
0.2
0.1
0.0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ AS
⧗ MN
MILLTOWN, MONTANA, 1983-84

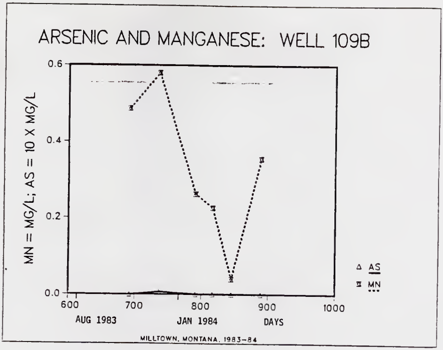

IRON AND MANGANESE: WELL 99(A)
CONCENTRATION IN MG/L
0.4
0.3
0.2
0.1
0.0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
△ Mn
⧗ Fe
MILLTOWN, MONTANA, 1983-84

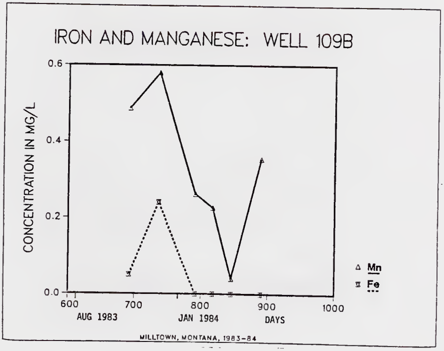

ARSENIC AND MANGANESE: WELL 101B
MN = MG/L; AS = 10 X MG/L
11
10
9
8
7
6
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
△ AS
⧗ MN
MILLTOWN, MONTANA, 1983

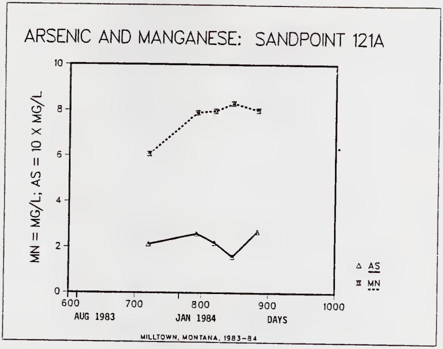

IRON AND MANGANESE: WELL 101B
CONCENTRATION IN MG/L
20
18
16
14
12
10
8
400
500
600
700
800
JAN 1983
DAYS
JAN 1984
△ Mn
⧗ Fe
MILLTOWN, MONTANA, 1983


ARSENIC AND MANGANESE: WELL 101B
MN = MG/L; AS = 10 X MG/L
11
10
9
8
7
6
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
AS
MN
MILLTOWN, MONTANA, 1983-84


IRON AND MANGANESE: WELL 101B
CONCENTRATION IN MG/L
25
20
15
10
5
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
MN
FE
MILLTOWN, MONTANA, 1983-84

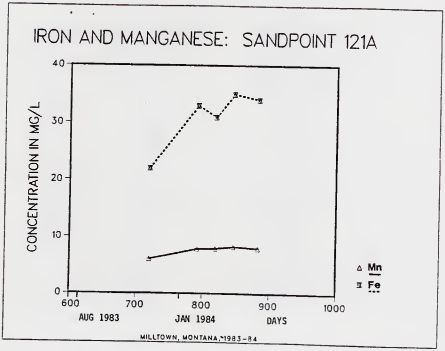

ARSENIC AND MANGANESE: WELL 109B
MN = MG/L; AS = 10 X MG/L
0.6
0.4
0.2
0.0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
AS
MN
MILLTOWN, MONTANA, 1983-84


IRON AND MANGANESE: WELL 109B
CONCENTRATION IN MG/L
0.6
0.4
0.2
0.0
600
700
800
900
1000
AUG 1983
JAN 1984
DAYS
Mn
Fe
MILLTOWN, MONTANA, 1983-84



ARSENIC AND MANGANESE: SANDPOINT 121A

MILLTOWN, MONTANA, 1983-84



IRON AND MANGANESE: SANDPOINT 121A

MILLTOWN, MONTANA, 1983-84

APPENDIX E

TABLES OF WATER LEVEL DATA, CLARK FORK AND BLACKFOOT RIVER DISCHARGE, AND MILLTOWN RESERVOIR STAGE FROM FEBRUARY, 1982 THROUGH JUNE, 1984

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820226	A	3246.48	61.0	3259.60	2560	927
820308	A	3244.43	61.0	3259.30	2040	726
820224	B	3246.02	65.0	3259.80	3300	1100
820305	B	3244.13	65.0	3259.50	2230	777
820319	B	3243.04	65.0	3259.60	2280	902
830907	B	3242.20	65.0	3258.90	1740	682
831123	B	3238.01	65.0	3252.50	1660	646
820224	C	3246.21	63.0	3259.80	3300	1100
820303	C1	3250.23	82.5	3259.70	2400	815
830906	C1	3248.03	82.5	3259.00	1770	690
831123	C1	3242.43	82.5	3252.50	1660	646
820303	C2	3246.52	160.0	3259.70	2400	815
830906	C2	3244.09	160.0	3259.00	1770	690
831123	C2	3239.02	160.0	3252.50	1660	646
820303	C3	3249.19	107.5	3259.70	2400	815
820319	C3	3247.29	107.5	3259.60	2280	902
830906	C3	3244.28	107.5	3259.00	1770	690
820303	C4	3230.30	100.5	3259.70	2400	815
820319	C4	3229.45	100.5	3259.60	2280	902
830906	C4	3228.24	100.5	3259.00	1770	690
831123	C4	3235.16	100.5	3252.50	1660	646
820303	C5	3250.58	54.5	3259.70	2400	815
820319	C5	3248.80	54.5	3259.60	2280	902
830906	C5	3250.93	54.5	3259.00	1770	690
831123	C5	3242.81	54.5	3252.50	1660	646
820303	C8	3236.70	118.5	3259.70	2400	815
820319	C8	3235.55	118.5	3259.60	2280	902
830906	C8	3234.44	118.5	3259.00	1770	690
831123	C8	3229.48	118.5	3252.50	1660	646
820303	C21	3233.18	-9.0	3259.70	2400	815
830906	C21	3228.42	-9.0	3259.00	1770	690
820224	D	3247.11	62.5	3259.80	3300	1100
820305	D	3244.68	62.5	3259.50	2230	777
820319	D	3244.23	62.5	3259.60	2280	902
830907	D	3242.39	62.5	3258.90	1740	682
831123	D	3238.07	62.5	3252.50	1660	646
820224	E	3245.83	65.0	3259.80	3300	1100
820305	E	3244.32	65.0	3259.50	2230	777
830907	E	3242.36	65.0	3258.90	1740	682
831123	E	3237.80	65.0	3252.50	1660	646
820226	F	3246.19	63.0	3259.60	2560	927
830305	F	3244.62	63.0	3259.00	2320	893
831122	F	3237.75	63.0	3252.20	1820	655
820226	G	3247.58	58.3	3259.60	2560	927
820305	G	3246.02	58.3	3259.50	2230	777
820319	G	3244.85	58.3	3259.60	2280	902
820324	G	3244.23	58.3	3259.60	2200	903
820326	G	3244.10	58.3	3259.50	2080	847
820327	G	3244.03	58.3	3259.50	2140	872
820328	G	3244.01	58.3	3259.60	2280	933
820329	G	3243.99	58.3	3259.80	2460	1020
820330	G	3244.03	58.3	3259.60	2460	1020
820331	G	3244.05	58.3	3259.20	2410	993
820401	G	3243.96	58.3	3259.30	2350	986
820402	G	3243.87	58.3	3259.20	2320	959
820403	G	3243.79	58.3	3259.20	2280	964
820404	G	3243.72	58.3	3259.10	2280	965
820405	G	3243.67	58.3	3259.10	2230	945
820406	G	3243.57	58.3	3259.00	2190	931

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820407	G	3243.48	58.3	3259.00	2180	911
820408	G	3243.42	58.3	3258.90	2090	872
820409	G	3243.37	58.3	3258.90	2080	880
820410	G	3243.31	58.3	3258.90	2130	879
820411	G	3243.24	58.3	3259.30	2290	1040
820412	G	3243.30	58.3	3259.80	3540	1550
820413	G	3243.53	58.3	3259.70	4530	2000
820414	G	3243.69	58.3	3259.70	4800	2230
820415	G	3243.85	58.3	3259.30	4740	2220
820416	G	3243.86	58.3	3259.80	4200	2040
820417	G	3243.95	58.3	3259.40	3960	1940
820418	G	3244.01	58.3	3259.50	3810	1930
820419	G	3244.02	58.3	3259.60	3640	1850
820420	G	3244.05	58.3	3259.50	3430	1740
820421	G	3244.10	58.3	3259.80	3340	1690
820422	G	3244.12	58.3	3259.90	3430	1790
820423	G	3244.13	58.3	3259.20	4050	2140
820424	G	3244.14	58.3	3259.50	5070	2700
820425	G	3244.15	58.3	3259.40	5770	3050
820426	G	3244.17	58.3	3259.60	5960	3150
820427	G	3244.25	58.3	3259.70	6060	3260
820428	G	3244.38	58.3	3259.70	6470	3500
820429	G	3244.53	58.3	3260.00	6870	3640
820430	G	3244.65	58.3	3260.00	6810	3620
820501	G	3244.69	58.3	3259.90	6690	3620
820502	G	3244.76	58.3	3259.70	7090	3830
820503	G	3244.81	58.3	3259.70	8330	4440
820504	G	3244.92	58.3	3259.80	9060	4850
820505	G	3245.01	58.3	3259.70	8820	4780
820506	G	3245.12	58.3	3259.90	8090	4490
820507	G	3245.24	58.3	3259.80	7750	4310
820508	G	3245.30	58.3	3259.70	7700	4300
820509	G	3245.38	58.3	3259.40	7600	4260
820510	G	3245.41	58.3	3259.40	7350	4110
820511	G	3245.41	58.3	3259.40	6930	3870
820512	G	3245.35	58.3	3259.20	6570	3700
820513	G	3245.23	58.3	3259.10	6420	3640
820514	G	3245.14	58.3	3259.30	6580	3810
820515	G	3245.11	58.3	3259.50	7270	4320
820516	G	3245.18	58.3	3259.80	8530	5120
820517	G	3245.22	58.3	3260.00	10000	6010
820518	G	3245.49	58.3	3259.60	11800	7010
820519	G	3245.81	58.3	3259.70	12900	7590
820520	G	3246.02	58.3	3259.40	12700	7340
820521	G	3246.20	58.3	3259.30	12100	7070
820522	G	3246.33	58.3	3259.40	12200	7270
820523	G	3246.44	58.3	3259.70	13300	7930
820524	G	3246.83	58.3	3259.70	14100	8280
820525	G	3246.95	58.3	3259.70	14400	8530
820526	G	3247.22	58.3	3259.60	15800	9430
820527	G	3247.46	58.3	3260.10	17400	9570
820528	G	3247.71	58.3	3259.90	17200	8750
820529	G	3247.80	58.3	3259.40	15300	7680
820530	G	3247.78	58.3	3258.40	13600	6780
820531	G	3247.65	58.3	3257.10	12000	6030
820601	G	3247.20	58.3	3258.10	10900	5520
820602	G	3247.03	58.3	3257.70	10200	5230
820603	G	3246.84	58.3	3257.70	10000	5130
820604	G	3246.69	58.3	3257.80	10400	5410

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820605	G	3246.58	58.3	3257.90	11000	5840
820606	G	3246.52	58.3	3258.10	11200	6030
820607	G	3246.49	58.3	3258.10	10900	5940
820608	G	3246.43	58.3	3257.90	10600	5760
820609	G	3246.43	58.3	3257.80	10400	5550
820610	G	3246.34	58.3	3257.60	10000	5460
820611	G	3246.29	58.3	3257.80	10100	5740
820612	G	3246.42	58.3	3258.20	11000	6380
820613	G	3246.77	58.3	3259.20	13200	7990
820614	G	3247.16	58.3	3259.80	15700	8990
820615	G	3247.16	58.3	3259.70	16800	9250
820616	G	3247.42	58.3	3259.60	17300	9610
820617	G	3247.66	58.3	3259.80	18100	9950
820618	G	3247.86	58.3	3259.70	18000	9590
820619	G	3248.02	58.3	3259.40	17100	8990
820620	G	3248.10	58.3	3259.50	16300	8690
820621	G	3248.16	58.3	3259.70	16000	8540
820622	G	3248.19	58.3	3259.60	15500	8370
820623	G	3248.23	58.3	3259.60	15300	8200
820624	G	3248.23	58.3	3259.60	15400	7940
820625	G	3248.26	58.3	3259.20	14700	7310
820626	G	3248.19	58.3	3259.20	14600	7320
820627	G	3248.13	58.3	3259.10	14100	7050
820628	G	3248.08	58.3	3259.00	13700	6750
820629	G	3248.02	58.3	3259.20	13900	6910
820630	G	3248.06	58.3	3259.40	14400	7370
820701	G	3248.08	58.3	3259.00	13800	7160
820702	G	3248.01	58.3	3259.00	13200	6890
820703	G	3247.90	58.3	3258.70	12100	6410
820704	G	3247.76	58.3	3258.40	10800	5680
820705	G	3247.56	58.3	3257.80	9750	5100
820706	G	3247.35	58.3	3257.20	9030	4660
820707	G	3247.14	58.3	3256.50	8230	4270
820708	G	3246.87	58.3	3256.30	7780	4060
820709	G	3246.71	58.3	3256.00	7400	3850
820710	G	3246.47	58.3	3255.60	7080	3650
820711	G	3246.25	58.3	3254.80	6670	3420
820712	G	3246.04	58.3	3254.80	6280	3220
820713	G	3245.88	58.3	3255.60	6070	3080
820714	G	3245.67	58.3	3255.70	6310	3160
820715	G	3245.55	58.3	3255.10	6580	3110
820716	G	3245.37	58.3	3253.90	6010	2890
820717	G	3245.21	58.3	3253.70	5790	2820
820718	G	3245.02	58.3	3253.60	5460	2690
820719	G	3244.80	58.3	3253.50	5140	2550
820720	G	3244.59	58.3	3253.20	4850	2390
820721	G	3244.37	58.3	3252.60	4570	2240
820722	G	3244.17	58.3	3252.60	4340	2110
820723	G	3243.97	58.3	3252.60	4100	2020
820724	G	3243.78	58.3	3252.60	3870	1920
820725	G	3243.62	58.3	3252.60	3760	1850
820726	G	3243.42	58.3	3252.60	3670	1780
820727	G	3243.24	58.3	3252.50	3520	1710
820728	G	3243.10	58.3	3252.60	3380	1660
820729	G	3242.95	58.3	3254.00	3010	1600
820730	G	3243.05	58.3	3259.50	2680	1530
820731	G	3243.56	58.3	3259.80	2900	1500
820801	G	3243.95	58.3	3259.70	2820	1440
820802	G	3244.24	58.3	3259.60	2770	1430

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820803	G	3244.41	58.3	3259.50	2660	1390
820804	G	3244.53	58.3	3259.30	2650	1370
820805	G	3244.47	58.3	3258.60	2490	1320
820806	G	3244.42	58.3	3258.60	2390	1270
820807	G	3244.42	58.3	3258.60	2250	1220
820808	G	3244.46	58.3	3258.70	2220	1190
820809	G	3244.49	58.3	3258.80	2210	1180
820810	G	3244.50	58.3	3258.80	2210	1150
820811	G	3244.49	58.3	3258.80	2140	1150
820812	G	3244.47	58.3	3257.50	2280	1130
820813	G	3244.32	58.3	3256.90	2170	1120
820814	G	3244.17	58.3	3256.90	2070	1100
820815	G	3244.09	58.3	3256.90	2080	1060
820816	G	3243.96	58.3	3257.80	1940	1040
820817	G	3243.89	58.3	3258.30	1900	1010
820818	G	3243.84	58.3	3258.20	1860	988
820819	G	3243.80	58.3	3259.00	1750	984
820820	G	3253.85	58.3	3259.20	1750	952
820821	G	3243.91	58.3	3259.20	1720	934
820822	G	3243.95	58.3	3259.20	1720	919
820823	G	3243.97	58.3	3259.10	1690	894
820824	G	3243.94	58.3	3259.10	1650	874
820825	G	3243.92	58.3	3259.00	1630	855
820826	G	3243.83	58.3	3259.50	1570	839
820827	G	3243.84	58.3	3259.50	1560	817
820828	G	3243.82	58.3	3259.50	1540	801
820829	G	3243.79	58.3	3259.40	1510	788
820830	G	3243.75	58.3	3259.40	1500	789
820831	G	3243.70	58.3	3259.40	1520	801
820901	G	3243.65	58.3	3259.40	1540	800
820902	G	3243.63	58.3	3259.40	1540	783
820903	G	3243.61	58.3	3259.40	1520	738
820904	G	3243.57	58.3	3259.40	1500	738
820905	G	3243.55	58.3	3259.40	1480	730
820906	G	3243.52	58.3	3259.30	1480	727
820907	G	3243.49	58.3	3259.20	1500	726
820908	G	3243.29	58.3	3259.30	1510	716
820909	G	3243.29	58.3	3259.30	1480	709
820910	G	3243.23	58.3	3259.20	1470	704
820911	G	3243.19	58.3	3259.30	1450	709
820912	G	3243.15	58.3	3259.30	1490	719
820913	G	3243.13	58.3	3259.50	1610	753
820914	G	3243.14	58.3	3259.60	1720	761
820915	G	3243.20	58.3	3259.30	1870	784
820916	G	3243.18	58.3	3259.30	1870	785
820917	G	3243.19	58.3	3259.30	1900	779
820918	G	3243.19	58.3	3259.30	1900	775
820919	G	3243.18	58.3	3259.20	1880	764
820920	G	3243.15	58.3	3259.20	1880	751
820921	G	3243.14	58.3	3259.30	1920	762
820922	G	3243.14	58.3	3259.10	1930	750
820923	G	3243.14	58.3	3259.10	1890	743
820924	G	3243.14	58.3	3259.10	1870	731
820925	G	3243.13	58.3	3259.20	1870	720
820926	G	3243.12	58.3	3259.30	1900	718
820927	G	3243.14	58.3	3259.30	2120	785
820928	G	3243.31	58.3	3259.60	2490	865
820929	G	3243.54	58.3	3259.70	2630	899
820930	G	3243.78	58.3	3259.60	2540	863

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
821001	G	3244.07	58.3	3259.40	2430	823
821002	G	3244.08	58.3	3259.40	2360	801
821003	G	3244.09	58.3	3259.40	2330	798
821004	G	3244.08	58.3	3259.40	2360	799
821005	G	3244.07	58.3	3259.40	2420	810
821006	G	3244.07	58.3	3259.40	2390	796
821007	G	3244.00	58.3	3259.40	2380	789
821008	G	3244.00	58.3	3259.40	2350	796
821009	G	3243.97	58.3	3259.40	2320	799
821010	G	3243.96	53.3	3259.30	2270	794
821011	G	3243.91	58.3	3259.50	2250	794
821012	G	3243.86	58.3	3259.40	2230	789
821013	G	3243.98	58.3	3259.30	2180	786
821014	G	3244.03	58.3	3259.20	2150	780
821015	G	3244.09	58.3	3259.20	2130	779
821016	G	3244.15	58.3	3259.20	2120	782
821017	G	3244.24	58.3	3259.10	2130	791
821018	G	3244.27	58.3	3259.10	2200	809
821019	G	3244.30	58.3	3259.10	2160	805
821020	G	3244.32	58.3	3259.20	2140	770
821021	G	3244.17	58.3	3259.20	2100	755
821022	G	3244.06	58.3	3259.10	2080	742
821023	G	3244.02	58.3	3259.10	2090	734
821024	G	3244.00	58.3	3259.10	2080	736
821025	G	3243.99	58.3	3259.10	2080	733
821026	G	3243.99	58.3	3259.00	2180	753
821027	G	3243.93	58.3	3258.80	2260	777
821028	G	3243.91	58.3	3258.70	2250	764
821029	G	3243.87	58.3	3258.70	2150	760
821030	G	3243.86	58.3	3259.10	2140	755
821031	G	3244.02	58.3	3259.90	2050	742
821101	G	3244.07	58.3	3259.40	2110	736
821102	G	3243.99	58.3	3259.20	2040	729
821103	G	3243.91	58.3	3259.10	2000	720
821104	G	3243.81	58.3	3259.10	1970	714
821105	G	3243.74	58.3	3259.10	1970	716
821106	G	3243.68	58.3	3259.10	1990	735
821107	G	3243.64	58.3	3259.10	1990	727
821108	G	3243.60	58.3	3259.10	1940	712
821109	G	3243.51	58.3	3259.00	1840	698
821110	G	3243.44	58.3	3259.00	1920	700
821111	G	3243.35	58.3	3259.00	1900	681
821112	G	3243.27	58.3	3258.90	1780	647
821113	G	3243.19	58.3	3259.50	1780	640
821114	G	3243.17	58.3	3259.40	1770	610
821115	G	3243.16	58.3	3259.30	1590	590
821116	G	3243.19	58.3	3259.60	1660	620
821117	G	3243.30	58.3	3259.70	1850	660
821118	G	3243.37	58.3	3259.30	1860	680
821119	G	3243.38	58.3	3259.20	1890	683
821120	G	3243.31	58.3	3259.00	1870	679
821121	G	3243.20	58.3	3259.00	1840	668
821122	G	3243.10	58.3	3259.30	1740	656
821123	G	3243.04	58.3	3259.30	1640	606
821124	G	3242.97	58.3	3259.20	1450	550
821125	G	3242.92	58.3	3259.20	1420	520
821126	G	3242.93	58.3	3259.30	1460	560
821127	G	3243.04	58.3	3259.50	1560	600
821128	G	3243.21	58.3	3259.50	1710	620

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
821129	G	3243.48	58.3	3259.40	1790	669
821130	G	3243.74	58.3	3259.40	1760	653
821201	G	3243.91	58.3	3259.30	1720	647
821202	G	3243.99	58.3	3259.30	1700	636
821203	G	3244.06	58.3	3259.30	1710	642
821204	G	3244.08	58.3	3259.40	1750	653
821205	G	3244.10	58.3	3259.50	1760	629
821206	G	3244.09	58.3	3259.60	1800	649
821207	G	3244.03	58.3	3259.40	1700	560
821208	G	3243.89	58.3	3259.60	1400	400
821209	G	3243.85	58.3	3259.40	1300	410
821210	G	3243.83	58.3	3259.50	1250	390
821211	G	3243.91	58.3	3259.50	1250	430
821212	G	3244.07	58.3	3259.50	1400	500
821213	G	3244.26	58.3	3259.50	1600	600
821214	G	3244.53	58.3	3259.60	1800	660
821215	G	3244.86	58.3	3259.60	1870	700
821216	G	3245.20	58.3	3259.30	1890	731
821217	G	3245.55	58.3	3259.40	1960	739
821218	G	3245.81	58.3	3259.40	1930	716
821219	G	3245.87	58.3	3259.40	1870	704
821220	G	3246.49	58.3	3259.50	1780	686
821221	G	3245.86	58.3	3259.30	1770	673
821222	G	3245.82	58.3	3259.30	1790	702
821223	G	3245.72	58.3	3259.30	1800	680
821224	G	3245.59	58.3	3259.20	1700	660
821225	G	3245.46	58.3	3259.20	1470	560
821226	G	3245.33	58.3	3259.30	1320	500
821227	G	3245.23	58.3	3259.60	1450	460
821228	G	3245.24	58.3	3259.50	1300	430
821229	G	3245.34	58.3	3259.60	1200	420
821230	G	3245.49	58.3	3259.70	1250	410
821231	G	3245.68	58.3	3259.60	1200	410
830101	G	3245.85	58.3	3259.50	1150	405
830102	G	3245.91	58.3	3259.50	1150	400
830103	G	3246.16	58.3	3259.60	1300	440
830104	G	3246.36	58.3	3259.70	1500	500
830105	G	3246.56	58.3	3259.40	1800	600
830106	G	3246.77	58.3	3259.50	2200	660
830107	G	3247.03	58.3	3259.10	2540	720
830108	G	3247.21	58.3	3258.90	2400	820
830109	G	3247.23	58.3	3258.90	2730	840
830110	G	3247.13	58.3	3258.80	2420	820
830111	G	3246.99	58.3	3258.90	2380	780
830112	G	3246.88	58.3	3259.00	2290	720
830113	G	3246.70	58.3	3259.10	2040	700
830114	G	3246.53	58.3	3258.90	1920	660
830115	G	3246.31	58.3	3259.00	1680	620
830115	G	3246.09	58.3	3259.10	1580	605
830117	G	3245.87	58.3	3259.20	1590	600
830118	G	3245.76	58.3	3259.30	1630	610
830119	G	3245.78	58.3	3259.20	1600	610
830120	G	3245.80	58.3	3259.10	1520	580
830121	G	3245.79	58.3	3259.20	1530	580
830122	G	3245.74	58.3	3259.30	1570	590
830123	G	3245.64	58.3	3259.30	1570	590
830124	G	3245.52	58.3	3259.20	1530	580
830125	G	3245.39	58.3	3259.40	1540	580
830126	G	3245.28	58.3	3259.20	1520	580

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
830127	G	3245.16	58.3	3259.20	1530	580
830128	G	3245.03	58.3	3259.20	1560	580
830129	G	3244.95	58.3	3259.20	1540	580
830130	G	3244.84	58.3	3259.00	1480	560
830131	G	3244.73	58.3	3259.10	1500	540
830201	G	3244.65	58.3	3259.10	1500	540
830202	G	3244.56	58.3	3259.10	1480	540
830203	G	3244.48	58.3	3259.00	1450	540
830204	G	3244.40	58.3	3259.10	1300	510
830205	G	3244.29	58.3	3258.80	1170	460
830206	G	3244.19	58.3	3259.40	1180	450
830207	G	3244.13	58.3	3259.30	1340	475
830208	G	3244.12	58.3	3259.20	1430	520
830209	G	3244.18	58.3	3259.30	1420	530
830210	G	3244.25	58.3	3259.30	1420	540
830211	G	3244.34	58.3	3259.30	1410	540
830212	G	3244.40	58.3	3259.30	1430	550
830213	G	3244.39	58.3	3259.30	1770	580
830214	G	3244.37	58.3	3259.20	1930	610
830215	G	3244.37	58.3	3259.10	1800	649
830215	G	3244.35	58.3	3259.20	1830	683
830217	G	3244.32	58.3	3259.00	1870	666
830218	G	3244.29	58.3	3259.00	1900	660
830219	G	3244.24	58.3	3259.00	2470	794
830220	G	3244.28	58.3	3259.00	2580	1030
830221	G	3244.25	58.3	3258.80	2270	901
830222	G	3244.12	58.3	3259.20	2110	771
830223	G	3243.96	58.3	3259.30	2150	766
830224	G	3243.79	58.3	3259.40	2200	813
830225	G	-9.00	58.3	3259.40	2210	843
830226	G	-9.00	58.3	3259.40	2220	848
830227	G	-9.00	58.3	3259.20	2160	823
830228	G	-9.00	58.3	3259.00	1980	748
830301	G	-9.00	58.3	3259.00	1920	719
830302	G	-9.00	58.3	3259.00	1920	731
830303	G	3242.43	58.3	3259.00	2150	806
830304	G	3242.29	58.3	3259.00	2280	884
830305	G	3242.18	58.3	3259.00	2320	893
830306	G	3242.06	58.3	3258.80	2200	824
830307	G	3241.95	58.3	3258.90	2100	793
830308	G	3241.82	58.3	3258.80	2040	768
830309	G	3241.72	58.3	3258.80	2010	794
830310	G	3241.65	58.3	3259.10	2170	884
830311	G	3241.62	58.3	3259.30	2380	978
830312	G	3241.64	58.3	3259.50	2670	1170
830313	G	3241.80	58.3	3259.50	2840	1260
830314	G	3241.93	58.3	3259.50	2800	1250
830315	G	3242.04	58.3	3259.40	2700	1170
830316	G	3242.13	58.3	3259.30	2550	1100
830317	G	3242.11	58.3	3259.20	2420	1050
830318	G	3242.07	58.3	3259.00	2340	1000
830319	G	3241.97	58.3	3258.80	2200	932
830320	G	3241.85	58.3	3258.90	2040	898
830321	G	3241.74	58.3	3259.10	2060	890
830322	G	3241.66	58.3	3259.10	2260	884
830323	G	3241.59	58.3	3259.00	2070	873
830324	G	3241.50	58.3	3258.80	1990	865
830325	G	3241.41	58.3	3258.80	1960	852
830326	G	3241.33	58.3	3258.60	1940	832

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 DATE    WELL   ELEV    DEPTH  STAGE       CLFQ      BLKQ
830327    G    3241.25   58.3 3259.10      1870       821
830328    G    3241.19   58.3 3259.20      1900       823
830329    G    3241.17   58.3 3259.20      1890       822
830330    G    3241.13   58.3 3259.20      1900       866
830331    G    3241.13   58.3 3259.30      1990       906
830401    G    3241.14   58.3 3259.30      1980       902
830402    G    3241.15   58.3 3259.30      1970       914
830403    G    3241.17   58.3 3259.30      1900       927
830404    G    3241.19   58.3 3259.30      1970       912
830405    G    3241.18   58.3 3259.30      1920       886
830406    G    3241.17   58.3 3259.20      1870       873
830407    G    3241.14   58.3 3258.60      1910       869
830408    G    3241.11   58.3 3258.90      1850       869
830409    G    3241.10   58.3 3258.90      1870       870
830410    G    3241.09   58.3 3258.90      1910       887
830411    G    3241.09   58.3 3259.30      1900       882
830412    G    3241.10   58.3 3259.20      1870       871
830413    G    3241.09   58.3 3259.20      1850       854
830414    G    3241.07   58.3 3259.10      1810       841
830415    G    3241.06   58.3 3259.10      1760       834
830416    G    3241.05   58.3 3259.50      1770       830
830417    G    3241.08   58.3 3259.40      1780       836
830418    G    3241.12   58.3 3259.40      1820       868
830419    G    3241.14   58.3 3259.50      1900       917
830420    G    3241.20   58.3 3259.50      2030       997
830421    G    3241.20   58.3 3259.30      2220      1100
830422    G    3241.42   58.3 3259.60      2410      1230
830423    G    3241.60   58.3 3259.70      2740      1420
830424    G    3241.80   58.3 3259.80      3160      1730
830425    G    3242.05   58.3 3259.60      3880      2130
830426    G    3242.31   58.3 3259.70      4120      2240
830427    G    3242.52   58.3 3259.60      3920      2150
830428    G    3242.70   58.3 3259.40      3720      2030
830429    G    3242.83   58.3 3259.90      3440      1900
830430    G    3242.99   58.3 3259.90      3340      1800
830501    G    3243.13   58.3 3259.60      3260      1730
830502    G    3243.29   58.3 3259.60      3150      1690
830503    G    3243.25   58.3 3259.60      3170      1700
830504    G    3243.33   58.3 3259.60      3170      1690
830505    G    3243.38   58.3 3259.80      3180      1720
830506    G    3243.49   58.3 3259.70      3600      1930
830507    G    3253.64   58.3 3259.70      3840      2080
830508    G    3243.75   58.3 3259.70      3950      2240
830509    G    3243.88   58.3 3259.70      4230      2390
830510    G    3244.04   58.3 3259.80      4360      2440
830511    G    3244.21   58.3 3259.60      4210      2360
830512    G    3244.31   58.3 3259.80      4070      2230
830513    G    3244.35   58.3 3259.70      3890      2040
830514    G    3244.36   58.3 3259.80      3760      2040
830515    G    3244.38   58.3 3259.80      3770      2010
830516    G    3244.42   58.3 3259.80      3900      2040
830517    G    3244.49   58.3 3259.90      4000      2050
830518    G    3244.55   58.3 3259.80      4130      1990
830519    G    3244.65   58.3 3259.70      4560      2420
830520    G    3244.74   58.3 3259.80      4900      2620
830521    G    3244.83   58.3 3259.80      5130      2830
830522    G    3244.95   58.3 3259.80      5600      3180
830523    G    3245.12   58.3 3259.80      6300      3700
830524    G    3245.30   58.3 3259.80      7160      4360
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
830525	G	3245.39	58.3	3259.90	8490	5280
830526	G	3245.67	58.3	3260.10	10100	6350
830527	G	3245.81	58.3	3259.70	11700	7150
830528	G	3245.96	58.3	3259.90	12500	7270
830529	G	3246.13	58.3	3260.10	12800	7320
830530	G	3246.28	58.3	3260.10	13300	7550
830531	G	3246.43	58.3	3259.80	12900	7210
830601	G	3246.49	58.3	3259.80	11600	6500
830602	G	3246.44	58.3	3259.70	10200	5810
830603	G	3246.37	58.3	3259.40	9310	5300
830604	G	3246.21	58.3	3259.20	8790	5100
830605	G	3246.09	58.3	3259.00	8460	4940
830606	G	3245.95	58.3	3258.80	8050	4680
830607	G	3245.84	58.3	3258.50	7670	4500
830608	G	3245.75	58.3	3258.40	7490	4470
830609	G	3245.63	58.3	3258.30	7450	4460
830610	G	3245.53	58.3	3258.30	7430	4450
830611	G	3245.46	58.3	3258.20	7420	4410
830612	G	3245.38	58.3	3258.10	7280	4150
830613	G	3245.27	58.3	3257.80	6680	3740
830614	G	3245.16	58.3	3257.00	6000	3370
830615	G	3245.03	58.3	3256.60	5460	3760
830616	G	3244.87	58.3	3256.30	5240	3030
830617	G	3244.72	58.3	3254.80	5120	2890
830618	G	3244.57	58.3	3254.40	5110	2970
830619	G	3244.39	58.3	3254.30	5510	3130
830620	G	3244.23	58.3	3253.90	5150	2900
830621	G	3244.05	58.3	3253.40	4740	2690
830622	G	3243.82	58.3	3252.80	4520	2550
830623	G	3243.59	58.3	3252.30	4180	2350
830624	G	3243.38	58.3	3257.40	3610	2250
830625	G	3243.45	58.3	3259.60	3820	2200
830626	G	3243.80	58.3	3259.50	3790	2140
830627	G	3244.03	58.3	3259.80	3670	2090
830628	G	3244.25	58.3	3260.00	4070	2200
830629	G	3244.48	58.3	3260.10	4550	2370
830630	G	3244.73	58.3	3260.10	4700	2410
830701	G	3244.93	58.3	3259.70	4700	2430
830702	G	3244.97	58.3	3259.70	4540	2410
830703	G	3245.03	58.3	3259.70	4660	2380
830704	G	3245.06	58.3	3259.60	4410	2280
830705	G	3245.07	58.3	3259.80	4080	2140
830706	G	3245.10	58.3	3259.90	3820	2020
830707	G	3245.13	58.3	3259.80	3750	1970
830708	G	3245.12	58.3	3259.70	3590	1900
830709	G	3245.11	58.3	3259.70	3370	1820
830710	G	3245.15	58.3	3260.00	4460	2220
830711	G	3245.35	58.3	3259.80	7410	2920
830712	G	3245.43	58.3	3259.80	6410	2700
830713	G	3245.43	58.3	3260.00	5410	2370
830714	G	3245.43	58.3	3259.60	4920	2190
830715	G	3245.43	58.3	3260.00	4810	2130
830716	G	3245.42	58.3	3259.80	4610	2060
830717	G	3245.43	58.3	3259.80	4400	1970
830718	G	3245.39	58.3	3259.90	4160	1880
830719	G	3245.37	58.3	3260.00	4010	1810
830720	G	3245.36	58.3	3259.90	3850	1750
830721	G	3245.34	58.3	3259.80	3870	1750
830722	G	3245.33	58.3	3259.90	3690	1710

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 DATE   WELL    ELEV    DEPTH  STAGE        CLFQ     BLKQ
830723   G    3245.32   58.3  3259.90       3500     1610
830724   G    3245.27   58.3  3259.90       3340     1550
830725   G    3245.24   58.3  3259.90       3310     1530
830726   G    3245.19   58.3  3259.90       3200     1510
830727   G    3245.15   58.3  3259.80       3050     1430
830728   G    3245.10   58.3  3259.90       2860     1360
830729   G    3245.06   58.3  3259.90       2780     1300
830730   G    3245.03   58.3  3259.80       2680     1260
830731   G    3245.00   58.3  3259.70       2470     1210
830801   G    3244.97   58.3  3259.70       2610     1210
830802   G    3244.95   58.3  3259.40       2470     1170
830803   G    3244.89   58.3  3259.30       2380     1140
830804   G    3244.86   58.3  3259.20       2310     1130
830805   G    3244.84   58.3  3259.30       2250     1110
830806   G    3244.54   58.3  3259.30       2150     1060
830807   G    3244.47   58.3  3259.30       2040     1010
830808   G    3244.37   58.3  3259.00       1920      976
830809   G    3244.37   58.3  3259.20       1900      953
830810   G    3244.38   58.3  3259.20       1900      952
830811   G    3243.88   58.3  3259.50       2080     1050
830812   G    3243.88   58.3  3259.30       2300     1090
830813   G    3243.87   58.3  3258.60       2220     1020
830814   G    3243.84   58.3  3257.80       2150      967
830815   G    3243.84   58.3  3257.90       2010      926
830816   G    3243.85   58.3  3257.90       2120      913
830817   G    3243.34   58.3  3256.30       1930      898
830818   G    3243.31   58.3  3256.20       1860      864
830819   G    3243.31   58.3  3257.00       1670      828
830820   G    3243.31   58.3  3258.80       1660      810
830821   G    3243.31   58.3  3259.10       1790      785
830822   G    3243.31   58.3  3259.20       1810      806
830823   G    3243.39   58.3  3259.40       1990      842
830824   G    3243.56   58.3  3259.40       2080      842
830825   G    3243.71   58.3  3259.30       2020      817
830826   G    3243.79   58.3  3258.90       1940      798
830827   G    3243.85   58.3  3258.90       1940      778
830828   G    3243.89   58.3  3258.90       1910      764
830829   G    3243.89   58.3  3258.80       1880      750
830830   G    3243.86   58.3  3258.50       1800      731
830831   G    3243.79   58.3  3259.30       1750      714
830901   G    3243.80   58.3  3259.10       1770      710
830902   G    3243.82   58.3  3259.10       1820      722
830903   G    3243.86   58.3  3259.10       1840      712
830904   G    3243.87   58.3  3259.10       1830      714
830905   G    3243.89   58.3  3259.10       1800      703
830906   G    3243.85   58.3  3259.00       1770      690
830907   G    3243.79   58.3  3258.90       1740      682
830908   G    3243.71   58.3  3258.80       1720      680
830909   G    3243.63   58.3  3258.50       1710      685
830910   G    3243.64   58.3  3258.80       1730      687
830911   G    3243.64   58.3  3259.20       1900      751
830912   G    3243.57   58.3  3259.10       2010      773
830913   G    3243.60   58.3  3259.10       1980      760
830914   G    3243.67   58.3  3258.90       1920      729
830915   G    3243.68   58.3  3258.70       1870      706
830915   G    3243.64   58.3  3258.50       1850      694
830917   G    3243.65   58.3  3258.30       1830      679
830918   G    3243.65   58.3  3257.80       1810      679
830919   G    3243.23   58.3  3258.70       1850      712
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  DATE    WELL    ELEV    DEPTH  STAGE          CLFQ       BLKQ
 830920    G     3243.22   58.3  3258.90        1960        707
 830921    G     3243.26   58.3  3259.00        2020        709
 830922    G     3243.31   58.3  3259.10        2060        711
 830923    G     3243.36   58.3  3259.00        2070        704
 830924    G     3243.36   58.3  3259.10        2030        706
 830925    G     3243.38   58.3  3259.10        2010        700
 830926    G     3243.39   58.3  3259.00        1980        687
 830927    G     3243.38   58.3  3258.50        1950        678
 830928    G     3243.25   58.3  3258.20        1910        672
 830929    G     3243.15   58.3  3258.30        1890        667
 830930    G     3243.05   58.3  3258.60        1890        685
 831001    G     3243.01   58.3  3259.00        2010        714
 831002    G     3243.05   58.3  3259.00        2050        715
 831003    G     3243.10   58.3  3258.50        2110        719
 831004    G     3243.07   58.3  3258.20        1980        713
 831005    G     3243.03   58.3  3259.20        1960        711
 831006    G     3243.06   58.3  3258.20        2050        708
 831007    G     3242.99   58.3  3258.60        1870        701
 831008    G     3242.96   58.3  3258.90        1890        694
 831009    G       -9.00   58.3  3258.90        1950        724
 831010    G       -9.00   58.3  3258.00        2090        741
 831011    G     3242.97   58.3  3258.10        2120        733
 831012    G     3242.91   58.3  3256.80        2000        712
 831013    G     3242.77   58.3  3258.40        1970        708
 831014    G     3242.67   58.3  3257.80        1910        714
 831015    G     3242.61   58.3  3258.20        2000        708
 831016    G     3242.69   58.3  3258.60        2080        707
 831017    G     3242.77   58.3  3258.60        2050        702
 831018    G     3242.77   58.3  3259.20        2020        705
 831019    G     3242.81   58.3  3258.70        2060        701
 831020    G     3242.82   58.3  3259.10        2000        694
 831021    G     3242.84   58.3  3259.00        1980        687
 831022    G     3242.87   58.3  3258.90        1950        682
 831023    G     3242.87   58.3  3258.90        1940        680
 831024    G     3242.88   58.3  3258.80        1940        674
 831025    G     3242.91   58.3  3259.00        1960        677
 831026    G     3242.92   58.3  3259.00        1940        680
 831027    G     3242.91   58.3  3258.90        1920        680
 831028    G     3242.91   58.3  3258.90        1910        680
 831029    G     3242.90   58.3  3258.90        1890        680
 831030    G     3242.90   58.3  3258.80        1890        674
 831031    G     3242.89   58.3  3258.80        1930        672
 831101    G     3242.81   58.3  3257.60        1970        667
 831102    G     3242.69   58.3  3256.50        1950        669
 831103    G     3242.53   58.3  3256.50        1900        669
 831104    G     3242.57   58.3  3256.60        1970        676
 831105    G     3242.17   58.3  3255.00        1990        682
 831106    G     3241.94   58.3  3254.40        1980        694
 831107    G     3241.70   58.3  3254.10        2060        725
 831108    G     3241.48   58.3  3253.30        2130        714
 831109    G     3241.23   58.3  3253.10        2020        698
 831110    G     3240.97   58.3  3253.30        1960        686
 831111    G     3240.76   58.3  3252.80        1990        707
 831112    G     3240.53   58.3  3252.80        2050        718
 831113    G     3240.33   58.3  3252.80        2050        720
 831114    G     3240.16   58.3  3252.50        2030        712
 831115    G     3240.00   58.3  3252.50        2000        701
 831116    G     3239.85   58.3  3252.50        1970        691
 831117    G     3239.69   58.3  3252.40        1960        692
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  DATE    WELL    ELEV   DEPTH   STAGE          CLFQ         8LKQ
 831118    G    3239.54   58.3 3252.40          1960          698
 831119    G    3239.39   58.3 3252.20          1940          694
 831120    G    3239.35   58.3 3252.20          1920          696
 831121    G    3239.12   58.3 3252.20          1910          701
 831122    G    3239.00   58.3 3252.20          1820          655
 831123    G    3238.90   58.3 3252.50          1660          646
 831124    G    3238.79   58.3 3252.10          1780          681
 831125    G    3238.66   58.3 3252.70          1880          694
 831126    G    3238.56   58.3 3252.50          1850          705
 831127    G    3238.47   58.3 3252.30          1900          720
 831128    G    3238.38   58.3 3252.10          1880          715
 831129    G    3238.30   58.3 3252.30          1790          663
 831130    G    3238.24   58.3 3252.40          1530          540
 831201    G    3238.10   58.3 3252.70          1230          450
 831202    G    3238.12   58.3 3252.80          1200          430
 831203    G    3238.25   58.3 3252.90          1300          500
 831204    G    3238.45   58.3 3253.00          1500          580
 831205    G    3238.79   58.3 3252.60          1450          560
 831206    G    3239.21   58.3 3252.30          1400          540
 831207    G    3239.72   58.3 3252.70          1400          520
 831208    G    3240.27   58.3 3252.20          1500          540
 831209    G    3240.86   58.3 3252.50          1600          600
 831210    G    3241.41   58.3 3252.60          1700          640
 831211    G    3241.91   58.3 3252.60          1750          660
 831212    G    3242.25   58.3 3252.60          1700          650
 831213    G    3242.44   58.3 3252.20          1700          640
 831214    G      -9.00   58.3 3252.40          1700          640
 831215    G      -9.00   58.3 3252.40          1700          630
 831216    G      -9.00   58.3 3252.30          1680          620
 831217    G    3242.38   58.3 3251.30          1350          500
 831218    G    3242.27   58.3 3252.60           920          350
 831219    G    3242.14   58.3 3252.50           980          380
 831220    G    3242.10   58.3 3252.50          1050          400
 831221    G    3242.15   58.3 3252.30           960          380
 831222    G    3242.23   58.3 3252.70           900          350
 831223    G    3243.33   58.3 3252.50           890          330
 831224    G    3242.43   58.3 3252.60           880          330
 831225    G    3242.60   58.3 3252.60           910          350
 831226    G    3242.79   58.3 3253.00           940          360
 831227    G    3243.10   58.3 3252.50           980          370
 831228    G    3243.30   58.3 3252.90           980          360
 831229    G    3243.58   58.3 3252.60           940          350
 831230    G    3243.79   58.3 3252.50          1000          370
 831231    G    3243.90   58.3 3252.70          1100          420
 840101    G    3243.91   58.4 3252.90          1200           -9
 840102    G    3243.91   58.4 3252.50          1300           -9
 840103    G      -9.00   58.4 3252.70          1350           -9
 840104    G      -9.00   58.4 3252.70          1400           -9
 840105    G    3244.23   58.4 3259.30          1500           -9
 840106    G    3244.31   58.4 3259.30          1700           -9
 840107    G      -9.00   58.4 3259.10          1800           -9
 840108    G      -9.00   58.4 3257.00          1700           -9
 840109    G      -9.00   58.4 3251.40          1650           -9
 840110    G      -9.00   58.4 3254.60          1650           -9
 840111    G      -9.00   58.4 3253.50          1700           -9
 840112    G      -9.00   58.4 3252.30          1700           -9
 840113    G    3244.82   58.4 3252.20          1500           -9
 840114    G      -9.00   58.4 3252.60          1300           -9
 840115    G      -9.00   58.4 3251.40          1200           -9
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
840116	G	-9.00	58.4	3252.10	1200	-9
840117	G	3243.59	58.4	3252.10	1100	-9
840118	G	3243.42	58.4	3251.90	1000	-9
840119	G	3243.34	58.4	3251.80	910	-9
840120	G	3243.37	58.4	3252.00	960	-9
840121	G	3243.47	58.4	3251.10	1100	-9
840122	G	3243.60	58.4	3252.10	1200	-9
840123	G	3243.70	58.4	3251.90	1600	-9
840124	G	3243.77	58.4	3252.10	1700	-9
840125	G	3243.73	58.4	3252.10	1900	-9
840126	G	3243.64	58.4	3252.40	2200	-9
840127	G	3243.78	58.4	3252.60	2300	-9
840128	G	3243.76	58.4	3252.30	2340	-9
840129	G	3243.67	58.4	3252.60	2200	-9
840130	G	3243.15	58.4	3252.60	2040	-9
840131	G	3243.37	58.4	3252.50	1870	-9
840201	G	3243.16	58.4	3252.70	1790	-9
840202	G	3242.92	58.4	3253.00	1780	-9
840203	G	3242.72	58.4	3253.30	1700	-9
840204	G	3242.52	58.4	3253.50	1690	-9
840205	G	3242.34	58.4	3253.10	1640	-9
840206	G	3242.15	58.4	3253.50	1630	-9
840207	G	3241.96	58.4	3253.30	1620	-9
840208	G	3241.77	58.4	3253.40	1610	-9
840209	G	3241.57	58.4	3255.80	1470	-9
840210	G	3241.57	58.4	3259.60	1430	-9
840211	G	3241.78	58.4	3258.10	1660	-9
840212	G	3241.90	58.4	3257.90	1560	-9
840213	G	3241.98	58.4	3256.60	1650	-9
840214	G	3241.98	58.4	3259.20	1660	-9
840215	G	3242.09	58.4	3258.60	1650	-9
840216	G	3242.19	58.4	3259.80	1600	-9
840217	G	3242.35	58.4	3259.30	1550	-9
840218	G	3242.46	58.4	3259.40	1570	-9
840219	G	3242.77	58.4	3259.40	1480	-9
840220	G	3242.79	58.4	3259.40	1450	-9
840221	G	3242.86	58.4	3259.40	1500	-9
840222	G	3242.87	58.4	3259.30	1510	-9
840223	G	3242.93	58.4	3259.30	1470	-9
840224	G	3242.97	58.4	3259.30	1430	-9
840225	G	3242.97	58.4	3259.20	1450	-9
840226	G	3243.07	58.4	3259.20	1450	-9
840227	G	3243.10	58.4	3259.20	1410	-9
840228	G	3243.15	58.4	3259.30	1400	-9
840229	G	3243.17	58.4	3259.30	1450	-9
840301	G	3243.18	58.4	3258.90	1460	-9
840302	G	3243.18	58.4	3259.30	1470	-9
840303	G	3243.19	58.4	3259.10	1550	-9
840304	G	3243.19	58.4	3259.00	1530	-9
840305	G	3243.20	58.4	3258.70	1500	-9
840306	G	3243.17	58.4	3258.70	1420	-9
840307	G	3243.12	58.4	3259.00	1440	-9
840308	G	3243.12	58.4	3259.10	1490	-9
840309	G	3243.14	58.4	3259.20	1580	-9
840310	G	3243.22	58.4	3259.20	1700	-9
840311	G	3243.32	58.4	3259.30	1760	-9
840312	G	3243.46	58.4	3259.50	1810	-9
840313	G	3243.57	58.4	3259.50	1790	-9
840314	G	3243.67	58.4	3259.60	1880	-9

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  DATE    WELL    ELEV    DEPTH  STAGE          CLFQ        8LKQ
840315     G    3243.81    58.4 3259.50         2180          -9
840316     G    3243.87    58.4 3259.20         2090          -9
840317     G    3243.88    58.4 3259.30         2030          -9
840318     G    3243.88    58.4 3259.20         1980          -9
840319     G    3243.88    58.4 3259.00         1900          -9
840320     G    3243.88    58.4 3259.60         1830          -9
840321     G    3243.93    58.4 3259.70         2060          -9
840322     G    3243.94    58.4 3259.40         2190          -9
840323     G    3244.02    58.4 3259.30         2120          -9
840324     G    3244.06    58.4 3259.30         2120          -9
840325     G    3244.10    58.4 3259.30         2140          -9
840326     G    3244.16    58.4 3259.30         2160          -9
840327     G    3244.17    58.4 3259.30         2130          -9
840328     G    3244.19    58.4 3259.30         2110          -9
840329     G    3244.20    58.4 3259.20         2080          -9
840330     G    3244.20    58.4 3259.20         2040          -9
840331     G    3244.19    58.4 3259.10         2000          -9
840401     G    3244.17    58.4 3259.10         1970          -9
840402     G    3244.13    58.4 3259.00         1940          -9
840403     G    3244.07    58.4 3259.00         1910          -9
840404     G    3244.04    58.4 3258.90         1890          -9
840405     G    3244.03    58.4 3259.00         1920          -9
840406     G    3244.03    58.4 3259.20         2060          -9
840407     G    3244.07    58.4 3259.30         2200          -9
840408     G    3244.17    58.4 3259.40         2240          -9
840409     G    3244.22    58.4 3259.50         2280          -9
840410     G    3244.28    58.4 3259.50         2330          -9
840411     G    3244.31    58.4 3259.50         2320          -9
840412     G    3244.36    58.4 3259.50         2280          -9
840413     G    3244.37    58.4 3259.60         2240          -9
840414     G    3244.37    58.4 3259.60         2200          -9
840415     G    3244.38    58.4 3259.60         2180          -9
840416     G    3244.42    58.4 3259.60         2370          -9
840417     G    3244.47    58.4 3260.00         2950          -9
840418     G    3244.59    58.4 3259.90         3640          -9
840419     G    3244.70    58.4 3259.70         4550          -9
840420     G    3244.87    58.4 3259.30         6050          -9
840421     G    3244.90    58.4 3256.80         6500          -9
840422     G    3244.86    58.4 3256.80         6120          -9
840423     G    3244.79    58.4 3256.80         6060          -9
840424     G    3244.70    58.4 3255.40         6090          -9
840425     G    3244.54    58.4 3257.00         5400          -9
840426     G    3244.35    58.4 3258.90         4950          -9
840427     G    3244.28    58.4 3259.40         4690          -9
840428     G    3244.37    58.4 3259.30         4420          -9
840429     G    3244.39    58.4 3259.20         4170          -9
840430     G    3244.39    58.4 3259.30         3950          -9
840501     G    3244.38    58.4 3259.30         3760          -9
840502     G    3244.37    58.4 3259.30         3710          -9
840503     G    3244.36    58.4 3259.20         3650          -9
840504     G    3244.36    58.4 3259.20         3600          -9
840505     G    3244.37    58.4 3259.10         3520          -9
840506     G    3244.33    58.4 3259.00         3400          -9
840507     G    3244.26    58.4 3259.00         3280          -9
840508     G    3244.19    58.4 3259.40         2240          -9
840509     G    3244.12    58.4 3259.50         2280          -9
840510     G    3244.06    58.4 3259.30         3470          -9
840511     G    3244.06    58.4 3259.50         3670          -9
840512     G    3244.08    58.4 3259.60         3800          -9
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	8LKQ
840513	G	3244.16	58.4	3260.00	4260	-9
840514	G	3244.34	58.4	3259.30	5170	-9
840515	G	3244.42	58.4	3258.80	7650	-9
840516	G	3244.57	58.4	3259.60	11300	-9
840517	G	3244.77	58.4	3259.50	12300	-9
840518	G	3244.84	58.4	3259.70	11100	-9
840419	G	3244.90	58.4	3259.70	4550	-9
840520	G	3244.97	58.4	3259.90	10600	-9
840524	G	3245.37	58.4	3259.70	10200	-9
840525	G	3245.39	58.4	3259.50	9500	-9
840526	G	3245.37	58.4	3259.00	8660	-9
840527	G	3245.24	58.4	3258.80	8230	-9
840528	G	3245.16	58.4	3258.60	7860	-9
840529	G	3245.05	58.4	3258.50	7590	-9
840530	G	3244.97	58.4	3259.10	8100	-9
840531	G	3245.06	58.4	3259.80	10800	-9
840601	G	3245.26	58.4	3259.40	12000	-9
840602	G	3245.39	58.4	3259.50	10500	-9
840603	G	3245.45	58.4	3259.40	9350	-9
840604	G	3245.45	58.4	3259.20	8750	-9
840605	G	3245.46	58.4	3259.30	8800	-9
840606	G	3245.46	58.4	3259.30	9060	-9
840607	G	3245.46	58.4	3259.10	8760	-9
840608	G	3245.46	58.4	3258.80	-9	-9
840609	G	3245.37	58.4	3258.60	-9	-9
840610	G	3145.28	58.4	3258.30	-9	-9
840611	G	3245.28	58.4	3258.10	-9	-9
840612	G	3245.28	58.4	3259.20	-9	-9
840613	G	3245.28	58.4	3259.20	-9	-9
840614	G	3245.28	58.4	3259.40	-9	-9
840615	G	3245.39	58.4	3259.60	-9	-9
840616	G	3245.37	58.4	3259.80	-9	-9
840617	G	3245.37	58.4	3259.60	-9	-9
840618	G	3245.37	58.4	3259.60	-9	-9
840619	G	3245.52	58.4	3259.40	-9	-9
840620	G	3245.65	58.4	3259.30	-9	-9
840621	G	3245.66	58.4	3259.80	-9	-9
840622	G	3245.58	58.4	3259.60	-9	-9
840623	G	3245.75	58.4	3253.30	-9	-9
840624	G	3245.75	58.4	3253.50	-9	-9
840625	G	3245.76	58.4	3253.30	-9	-9
820227	H	3246.60	55.0	3259.50	2450	887
820319	H	3244.53	55.0	3259.60	2280	902
831122	H	3238.54	55.0	3252.20	1820	655
820301	H3	3254.31	85.5	3259.40	2220	808
830906	H3	3247.50	85.5	3259.00	1770	690
831123	H3	3249.22	85.5	3252.50	1660	646
820301	H4	3254.58	94.0	3259.40	2220	808
830906	H4	3252.69	94.0	3259.00	1770	690
820301	H8	3254.71	85.7	3259.40	2220	808
820319	H8	3252.67	85.7	3259.60	2280	902
830907	H8	3252.90	85.7	3258.90	1740	682
831123	H8	3249.96	85.7	3252.50	1660	646
820227	J	3247.68	76.0	3259.50	2450	887
830816	J	3243.86	76.0	3257.90	2120	913
830906	J	3244.07	76.0	3259.00	1770	690
831122	J	3239.20	76.0	3252.20	1820	655
820301	L	3245.22	68.2	3259.40	2220	808
831122	L	3237.74	68.2	3252.20	1820	655

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820310	M16	3236.14	59.3	3259.90	2690	1070
820319	M16	3233.73	59.5	3259.60	2280	902
820409	M16	3234.59	59.9	3258.90	2080	880
830906	M16	3235.19	59.5	3259.00	1770	690
831123	M16	3228.88	59.5	3252.50	1660	646
820310	M17	3233.80	78.0	3259.90	2690	1070
820319	M17	3243.28	78.0	3259.60	2280	902
820409	M17	3230.55	78.0	3258.90	2080	880
820504	M17	3231.99	78.0	3259.80	9060	4850
820510	M17	3232.51	78.0	3259.40	7350	4110
820517	M17	3232.63	78.0	3260.00	10000	6010
820524	M17	3233.48	78.0	3259.70	14100	8280
820601	M17	3234.17	78.0	3258.10	10900	5520
820608	M17	3232.35	78.0	3257.90	10600	5760
820618	M17	3230.52	78.0	3259.70	18000	9590
820623	M17	3235.38	78.0	3259.60	15300	8200
820629	M17	3235.33	78.0	3259.20	13900	6910
820708	M17	3234.29	78.0	3256.30	7780	4060
820713	M17	3232.83	78.0	3255.60	6070	3080
820716	M17	3232.86	78.0	3253.90	6010	2890
820719	M17	3231.47	78.0	3253.50	5140	2550
820727	M17	3229.59	78.0	3252.50	3520	1710
820806	M17	3232.19	78.0	3258.60	2390	1270
820823	M17	3230.15	78.0	3259.10	1690	894
820908	M17	3229.52	78.0	3259.30	1510	716
820924	M17	3231.15	78.0	3259.10	1870	731
821001	M17	3231.58	78.0	3259.40	2430	823
821008	M17	3231.57	78.0	3259.40	2350	796
821027	M17	3231.34	78.0	3258.80	2260	777
821115	M17	3230.67	78.0	3259.30	1590	590
830120	M17	3231.62	78.0	3259.10	1520	580
830128	M17	3229.73	78.0	3259.20	1560	580
830207	M17	3229.73	78.0	3259.30	1340	475
830215	M17	3230.44	78.0	3259.10	1800	649
830223	M17	3230.59	78.0	3259.30	2150	766
830309	M17	3229.24	78.0	3258.80	2010	794
830317	M17	3229.36	78.0	3259.20	2420	1050
830323	M17	3228.96	78.0	3259.00	2070	873
830331	M17	3228.66	78.0	3259.30	1990	906
830408	M17	3228.56	78.0	3258.90	1850	869
830417	M17	3228.78	78.0	3259.40	1780	836
830423	M17	3229.10	78.0	3259.70	2740	1420
830508	M17	3230.47	78.0	3259.70	3950	2240
830517	M17	3231.20	78.0	3259.90	4000	2050
830601	M17	3233.30	78.0	3259.80	11600	6500
830608	M17	3233.10	78.0	3258.40	7490	4470
830614	M17	3232.48	78.0	3257.00	6000	3370
830805	M17	3231.89	78.0	3259.30	2250	1110
830815	M17	3230.83	78.0	3257.90	2120	913
830906	M17	3230.85	78.0	3259.00	1770	690
831021	M17	3229.65	78.0	3259.00	1980	687
831103	M17	3229.08	78.0	3256.50	1900	669
831123	M17	3225.26	78.0	3252.50	1660	646
820226	2	3252.18	100.0	3259.60	2560	927
820319	2	3249.96	100.0	3259.60	2280	902
830907	2	3249.14	100.0	3258.90	1740	682
831123	2	3245.27	100.0	3252.50	1660	646
820301	6	3244.92	75.0	3259.40	2220	808
820303	6	3244.33	75.0	3259.70	2400	815

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820305	6	3243.77	75.0	3259.50	2230	777
820308	6	3243.77	75.0	3259.30	2040	726
820310	6	3243.51	75.0	3259.90	2690	1070
820312	6	3243.10	75.0	3259.70	3110	1320
820316	6	3242.99	75.0	3259.80	2710	1100
820317	6	3243.01	75.0	3259.80	2500	1010
820319	6	3242.82	75.0	3259.60	2280	902
820324	6	3242.65	75.0	3259.60	2200	903
820409	6	3241.35	75.0	3258.90	2080	880
820415	6	3241.74	75.0	3259.30	4740	2220
820421	6	3242.08	75.0	3259.80	3340	1690
820427	6	3242.22	75.0	3259.70	6060	3260
820504	6	3242.87	75.0	3259.80	9060	4850
820510	6	3243.33	75.0	3259.40	7350	4110
820517	6	3243.39	75.0	3260.00	10000	6010
820524	6	3244.67	75.0	3259.70	14100	8280
820601	6	3245.00	75.0	3258.10	10900	5520
820608	6	3244.32	75.0	3257.90	10600	5760
820618	6	3245.78	75.0	3259.70	18000	9590
820623	6	3246.11	75.0	3259.60	15300	8200
820629	6	3245.88	75.0	3259.20	13900	6910
820708	6	3244.67	75.0	3256.30	7780	4060
820711	6	3243.66	75.0	3254.80	6670	3420
820716	6	3243.14	75.0	3253.90	6010	2890
820719	6	3242.58	75.0	3253.50	5140	2550
820727	6	3241.09	75.0	3252.50	3520	1710
820808	6	3251.42	75.0	3258.70	2220	1190
820823	6	3242.42	75.0	3259.10	1690	894
820908	6	3241.82	75.0	3259.30	1510	716
820924	6	3241.26	75.0	3259.10	1870	731
821001	6	3242.03	75.0	3259.40	2430	823
821008	6	3241.98	75.0	3259.40	2350	796
821021	6	3242.00	75.0	3259.20	2100	755
821115	6	3241.04	75.0	3259.30	1590	590
830120	6	3243.62	75.0	3259.10	1520	580
830128	6	3242.85	75.0	3259.20	1560	580
830207	6	3241.78	75.0	3259.30	1340	475
830215	6	3242.13	75.0	3259.10	1800	649
830223	6	3241.67	75.0	3259.30	2150	766
830302	6	3240.59	75.0	3259.00	1920	731
830309	6	3239.77	75.0	3258.80	2010	794
830317	6	3240.11	75.0	3259.20	2420	1050
830323	6	3239.56	75.0	3259.00	2070	873
830408	6	3239.10	75.0	3258.90	1850	869
830417	6	3239.03	75.0	3259.40	1780	836
830423	6	3239.55	75.0	3259.70	2740	1420
830507	6	3241.45	75.0	3259.70	3840	2080
830517	6	3242.26	75.0	3259.90	4000	2050
830525	6	3243.35	75.0	3259.90	8490	5280
830601	6	3244.27	75.0	3259.80	11600	6500
830608	6	3243.53	75.0	3258.40	7490	4470
830614	6	3242.87	75.0	3257.00	6000	3370
830623	6	3241.41	75.0	3252.30	4180	2350
830701	6	3242.85	75.0	3259.70	4700	2430
830708	6	3242.95	75.0	3259.70	3590	1900

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830713   6    3243.31   75.0  3260.00      5410      2370
830720   6    3244.72   75.0  3259.90      3850      1750
830805   6    3247.13   75.0  3259.30      2250      1110
830906   6    3241.83   75.0  3259.00      1770       690
831123   6    3246.23   75.0  3252.50      1660       646
820308   8    3244.57   70.0  3259.30      2040       726
820319   8    3249.05   70.0  3259.60      2280       902
820319   88   3245.14   63.0  3259.60      2280       902
820324   88   3244.45   63.0  3259.60      2200       903
820325   88   3244.41   63.0  3259.50      2150       858
820326   88   3244.37   63.0  3259.50      2080       847
820327   88   3244.34   63.0  3259.50      2140       872
820328   88   3244.32   63.0  3259.60      2280       933
820329   88   3244.32   63.0  3259.80      2460      1020
820330   88   3244.32   63.0  3259.60      2460      1020
820331   88   3244.32   63.0  3259.20      2410       993
820401   88   3244.27   63.0  3259.30      2350       986
820402   88   3244.24   63.0  3259.20      2320       959
820403   88   3244.14   63.0  3259.20      2280       964
820404   88   3244.10   63.0  3259.10      2280       965
820405   88   3244.05   63.0  3259.10      2230       945
820406   88   3244.00   63.0  3259.00      2190       931
820407   88   3243.93   63.0  3259.00      2180       911
820408   88   3243.88   63.0  3258.90      2090       872
820409   88   3243.81   63.0  3258.90      2080       880
820410   88   3243.76   63.0  3258.90      2130       879
820411   88   3243.73   63.0  3259.30      2290      1040
820412   88   3243.77   63.0  3259.80      3540      1550
820413   88   3243.95   63.0  3259.70      4530      2000
820414   88   3244.05   63.0  3259.70      4800      2230
820415   88   3244.08   63.0  3259.30      4740      2220
820416   88   3244.11   63.0  3259.80      4200      2040
820417   88   3244.22   63.0  3259.40      3960      1940
820418   88   3244.25   63.0  3259.50      3810      1930
820419   88   3244.26   63.0  3259.60      3640      1850
820420   88   3244.27   63.0  3259.50      3430      1740
820421   88   3244.42   63.0  3259.80      3340      1690
820422   88   3244.42   63.0  3259.90      3430      1790
820423   88   3244.53   63.0  3259.20      4050      2140
820424   88   3244.52   63.0  3259.50      5070      2700
820425   88   3244.48   63.0  3259.40      5770      3050
820426   88   3244.45   63.0  3259.60      5960      3150
820427   88   3244.48   63.0  3259.70      6060      3260
820428   88   3244.59   63.0  3259.70      6470      3500
820429   88   3244.77   63.0  3260.00      6870      3640
820430   88   3244.78   63.0  3260.00      6810      3620
820501   88   3244.78   63.0  3259.90      6690      3620
820502   88   3244.78   63.0  3259.70      7090      3830
820503   88   3245.02   63.0  3259.70      8330      4440
820504   88   3245.10   63.0  3259.80      9060      4850
820505   88   3245.25   63.0  3259.70      8820      4780
820506   88   3245.36   63.0  3259.90      8090      4490
820507   88   3245.46   63.0  3259.80      7750      4310
820508   88   3245.54   63.0  3259.70      7700      4300
820509   88   3245.60   63.0  3259.40      7600      4260
820510   88   3245.59   63.0  3259.40      7350      4110
820511   88   3245.60   63.0  3259.40      6930      3870
820512   88   3245.53   63.0  3259.20      6570      3700
820513   88   3245.41   63.0  3259.10      6420      3640
820514   88   3245.30   63.0  3259.30      6580      3810
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  DATE    WELL    ELEV    DEPTH  STAGE          CLFQ       BLKQ
 820515    8B   3245.31   63.0  3259.50         7270       4320
 820516    8B   3245.41   63.0  3259.80         8530       5120
 820517    8B   3245.72   63.0  3260.00        10000       6010
 820518    8B   3245.84   63.0  3259.60        11800       7010
 820519    8B   3246.06   63.0  3259.70        12900       7590
 820520    8B     -9.00   63.0  3259.40        12700       7340
 820521    8B     -9.00   63.0  3259.30        12100       7070
 820522    8B     -9.00   63.0  3259.40        12200       7270
 820523    8B     -9.00   63.0  3259.70        13300       7930
 820524    8B   3247.03   63.0  3259.70        14100       8280
 820525    8B   3247.25   63.0  3259.70        14400       8530
 820526    8B   3247.52   63.0  3259.60        15800       9430
 820527    8B   3247.78   63.0  3260.10        17400       9570
 820528    8B   3248.02   63.0  3259.90        17200       8750
 820529    8B   3248.05   63.0  3259.40        15300       7680
 820530    8B   3247.80   63.0  3258.40        13600       6780
 820531    8B   3247.83   63.0  3257.10        12000       6030
 820601    8B   3247.38   63.0  3258.10        10900       5520
 820602    8B   3247.13   63.0  3257.70        10200       5230
 820603    8B   3246.50   63.0  3257.70        10000       5130
 820604    8B   3246.78   63.0  3257.80        10400       5410
 820605    8B   3246.73   63.0  3257.90        11000       5840
 820606    8B   3246.67   63.0  3258.10        11200       6030
 820607    8B   3246.65   63.0  3258.10        10900       5940
 820608    8B   3246.59   63.0  3257.90        10600       5760
 820609    8B   3246.56   63.0  3257.80        10400       5550
 820610    8B   3246.40   63.0  3257.60        10000       5460
 820611    8B   3246.46   63.0  3257.80        10100       5740
 820612    8B   3246.42   63.0  3258.20        11000       6380
 820613    8B   3246.52   63.0  3259.20        13200       7990
 820614    8B   3246.88   63.0  3259.80        15700       8990
 820615    8B   3247.26   63.0  3259.70        16800       9250
 820616    8B   3247.53   63.0  3259.60        17300       9610
 820617    8B   3247.76   63.0  3259.80        18100       9950
 820618    8B   3248.01   63.0  3259.70        18000       9590
 820619    8B   3248.15   63.0  3259.40        17100       8990
 820620    8B   3248.21   63.0  3259.50        16300       8690
 820621    8B   3248.26   63.0  3259.70        16000       8540
 820622    8B   3248.33   63.0  3259.60        15500       8370
 820623    8B   3248.36   63.0  3259.60        15300       8200
 820624    8B   3248.44   63.0  3259.60        15400       7940
 820625    8B   3248.45   63.0  3259.20        14700       7310
 820626    8B   3248.35   63.0  3259.20        14600       7320
 820627    8B   3248.31   63.0  3259.10        14100       7050
 820628    8B   3248.24   63.0  3259.00        13700       6750
 820629    8B   3248.18   63.0  3259.20        13900       6910
 820630    8B   3248.20   63.0  3259.40        14400       7370
 820701    8B   3248.23   63.0  3259.00        13800       7160
 820702    8B   3248.15   63.0  3259.00        13200       6890
 820703    8B   3248.04   63.0  3258.70        12100       6410
 820704    8B   3247.00   63.0  3258.40        10800       5680
 820705    8B   3247.68   63.0  3257.80         9750       5100
 820706    8B   3247.49   63.0  3257.20         9030       4660
 820707    8B   3247.26   63.0  3256.50         8230       4270
 820708    8B   3246.89   63.0  3256.30         7780       4060
 820709    8B   3246.76   63.0  3256.00         7400       3850
 820710    8B   3246.56   63.0  3255.60         7080       3650
 820711    8B   3246.35   63.0  3254.80         6670       3420
 820712    8B   3246.16   63.0  3254.80         6280       3220
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  DATE    WELL    ELEV    DEPTH   STAGE          CLFQ        BLKQ
 820713    88    3245.98   63.0  3255.60         6070        3080
 820714    88    3245.80   63.0  3255.70         6310        3160
 820715    88    3245.64   63.0  3255.10         6580        3110
 820716    88    3245.52   63.0  3253.90         6010        2890
 820717    88    3245.32   63.0  3253.70         5790        2820
 820718    88    3245.13   63.0  3253.60         5460        2690
 820719    88    3244.87   63.0  3253.50         5140        2550
 820720    88    3244.71   63.0  3253.20         4850        2390
 820721    88    3244.51   63.0  3252.60         4570        2240
 820722    88    3244.25   63.0  3252.60         4340        2110
 820723    88    3244.06   63.0  3252.60         4100        2020
 820724    88    3243.89   63.0  3252.60         3870        1920
 820725    88    3243.70   63.0  3252.60         3760        1850
 820726    88    3243.54   63.0  3252.60         3670        1780
 820727    88    3243.30   63.0  3252.50         3520        1710
 820728    88    3243.21   63.0  3252.60         3380        1660
 820729    88    3243.05   63.0  3254.00         3010        1600
 820730    88    3243.15   63.0  3259.50         2680        1530
 820731    88    3243.76   63.0  3259.80         2900        1500
 820801    88    3244.15   63.0  3259.70         2820        1440
 820802    88    3244.33   63.0  3259.60         2770        1430
 820803    88      -9.00   63.0  3259.50         2660        1390
 820804    88      -9.00   63.0  3259.30         2650        1370
 820805    88      -9.00   63.0  3258.60         2490        1320
 820806    88    3244.58   63.0  3258.60         2390        1270
 820807    88    3244.59   63.0  3258.60         2250        1220
 820808    88    3244.63   63.0  3258.70         2220        1190
 820809    88    3244.66   63.0  3258.80         2210        1180
 820810    88    3244.68   63.0  3258.80         2210        1150
 820811    88    3244.66   63.0  3258.80         2140        1150
 820812    88    3244.64   63.0  3257.50         2280        1130
 820813    88    3244.50   63.0  3256.90         2170        1120
 820814    88    3244.31   63.0  3256.90         2070        1100
 820815    88    3244.24   63.0  3256.90         2080        1060
 820816    88    3244.14   63.0  3257.80         1940        1040
 820817    88    3244.02   63.0  3258.30         1900        1010
 820818    88    3244.00   63.0  3258.20         1860         988
 820819    88    3243.40   63.0  3259.00         1750         984
 820820    88    3244.01   63.0  3259.20         1750         952
 820821    88    3244.06   63.0  3259.20         1720         934
 820822    88    3244.09   63.0  3259.20         1720         919
 820823    88    3244.15   63.0  3259.10         1690         894
 820824    88    3244.09   63.0  3259.10         1650         874
 820825    88    3244.05   63.0  3259.00         1630         855
 820826    88    3244.02   63.0  3259.50         1570         839
 820827    88    3244.01   63.0  3259.50         1560         817
 820828    88    3243.99   63.0  3259.50         1540         801
 820829    88    3243.96   63.0  3259.40         1510         788
 820830    88    3243.91   63.0  3259.40         1500         789
 820831    88    3243.88   63.0  3259.40         1520         801
 820901    88    3243.83   63.0  3259.40         1540         800
 820902    88    3243.80   63.0  3259.40         1540         783
 820903    88    3243.77   63.0  3259.40         1520         738
 820904    88    3243.75   63.0  3259.40         1500         738
 820905    88    3243.72   63.0  3259.40         1480         730
 820906    88    3243.68   63.0  3259.30         1480         727
 820907    88    3243.65   63.0  3259.20         1500         726
 820908    88    3243.63   63.0  3259.30         1510         716
 820909    88    3243.61   63.0  3259.30         1480         709
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
820910	8B	3243.58	63.0	3259.20	1470	704
820911	8B	3243.53	63.0	3259.30	1450	709
820912	8B	3243.50	63.0	3259.30	1490	719
820913	8B	3243.47	63.0	3259.50	1610	753
820913	8B	3243.47	63.0	3259.50	1610	753
820914	8B	3243.50	63.0	3259.60	1720	761
820915	8B	3243.56	63.0	3259.30	1870	784
820916	8B	3243.53	63.0	3259.30	1870	785
820917	8B	3243.54	63.0	3259.30	1900	779
820918	8B	3243.56	63.0	3259.30	1900	775
820919	8B	3243.55	63.0	3259.20	1880	764
820920	8B	3243.51	63.0	3259.20	1880	751
820921	8B	3243.48	63.0	3259.30	1920	762
820922	8B	3243.50	63.0	3259.10	1930	750
820924	8B	3243.42	63.0	3259.10	1870	731
820925	8B	3243.40	63.0	3259.20	1870	720
820926	8B	3243.40	63.0	3259.30	1900	718
820927	8B	3243.40	63.0	3259.30	2120	785
820928	8B	3243.56	63.0	3259.60	2490	865
820929	8B	3243.80	63.0	3259.70	2630	899
820930	8B	3244.00	63.0	3259.60	2540	863
821001	8B	3244.21	63.0	3259.40	2430	823
821002	8B	3244.16	63.0	3259.40	2360	801
821003	8B	3244.17	63.0	3259.40	2330	798
821004	8B	3244.16	63.0	3259.40	2360	799
821005	8B	3244.14	63.0	3259.40	2420	810
821006	8B	3244.15	63.0	3259.40	2390	796
821007	8B	3244.13	63.0	3259.40	2380	789
821008	8B	3244.09	63.0	3259.40	2350	796
821009	8B	3244.06	63.0	3259.40	2320	799
821010	8B	3244.03	63.0	3259.30	2270	794
821011	8B	3243.98	63.0	3259.50	2250	794
821012	8B	3243.94	63.0	3259.40	2230	789
821013	8B	3243.89	63.0	3259.30	2180	786
821014	8B	3243.91	63.0	3259.20	2150	780
821015	8B	3243.95	63.0	3259.20	2130	779
821016	8B	3244.01	63.0	3259.20	2120	782
821017	8B	3244.10	63.0	3259.10	2130	791
821018	8B	3244.15	63.0	3259.10	2200	809
821019	8B	3244.15	63.0	3259.10	2180	805
821020	8B	3244.19	63.0	3259.20	2140	770
821021	8B	3244.18	63.0	3259.20	2100	755
821022	8B	3244.16	63.0	3259.10	2080	742
821023	8B	3244.13	63.0	3259.10	2090	734
821024	8B	3244.11	63.0	3259.10	2080	736
821025	8B	3244.12	63.0	3259.10	2080	733
821026	8B	3244.10	63.0	3259.00	2180	753
821027	8B	3244.26	63.0	3258.80	2260	777
821028	8B	3244.26	63.0	3258.70	2250	764
821029	8B	3244.21	63.0	3258.70	2150	760
821030	8B	3244.20	63.0	3259.10	2140	755
821031	8B	3244.31	63.0	3259.90	2050	742
821101	8B	3244.42	63.0	3259.40	2110	736
821102	8B	3244.35	63.0	3259.20	2040	729
821103	8B	3244.26	63.0	3259.10	2000	720
821104	8B	3244.18	63.0	3259.10	1970	714
821105	8B	3244.20	63.0	3259.10	1970	716
821106	8B	3244.14	63.0	3259.10	1990	735
821107	8B	3244.02	63.0	3259.10	1990	727

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 DATE    WELL   ELEV    DEPTH  STAGE          CLFQ        BLKQ
821108   8B    3243.97   63.0 3259.10          1940         712
821109   8B    3243.89   63.0 3259.00          1840         698
821110   8B    3243.80   63.0 3259.00          1920         700
821111   8B    3243.73   63.0 3259.00          1900         681
821112   8B    3243.64   63.0 3258.90          1780         647
821113   8B    3243.58   63.0 3259.50          1780         640
821114   8B    3243.56   63.0 3259.40          1770         610
821115   8B    3243.50   63.0 3259.30          1590         590
821116   8B    3243.53   63.0 3259.60          1660         620
821117   8B    3243.63   63.0 3259.70          1850         660
821118   8B    3243.73   63.0 3259.30          1860         680
821119   8B    3243.76   63.0 3259.20          1890         683
821120   8B    3243.68   63.0 3259.00          1870         679
821121   8B    3243.57   63.0 3259.00          1840         668
821122   8B    3243.46   63.0 3259.30          1740         656
821123   8B    3240.40   63.0 3259.30          1640         606
821124   8B    3243.30   63.0 3259.20          1450         550
821125   8B    3243.26   63.0 3259.20          1420         520
821126   8B    3243.26   63.0 3259.30          1460         560
821127   8B    3243.39   63.0 3259.50          1560         600
821128   8B    3243.57   63.0 3259.50          1710         620
821129   8B    3243.87   63.0 3259.40          1790         669
821130   8B       -9.00  63.0 3259.40          1760         653
821201   8B       -9.00  63.0 3259.30          1720         647
821202   8B       -9.00  63.0 3259.30          1700         636
821203   8B       -9.00  63.0 3259.30          1710         642
821204   8B       -9.00  63.0 3259.40          1750         653
821205   8B       -9.00  63.0 3259.50          1760         629
821206   8B       -9.00  63.0 3259.60          1800         649
821207   8B       -9.00  63.0 3259.40          1700         560
821208   8B       -9.00  63.0 3259.60          1400         400
821209   8B       -9.00  63.0 3259.40          1300         410
821210   8B    3244.11   63.0 3259.50          1250         390
821211   8B    3244.20   63.0 3259.50          1250         430
821212   8B    3244.30   63.0 3259.50          1400         500
821213   8B    3244.51   63.0 3259.50          1600         600
821214   8B    3244.79   63.0 3259.60          1800         660
821215   8B       -9.00  63.0 3259.60          1870         700
821216   8B       -9.00  63.0 3259.30          1890         731
821217   8B       -9.00  63.0 3259.40          1960         739
821218   8B       -9.00  63.0 3259.40          1930         716
821219   8B       -9.00  63.0 3259.40          1870         704
821220   8B       -9.00  63.0 3259.50          1780         686
821221   8B       -9.00  63.0 3259.30          1770         673
821222   8B       -9.00  63.0 3259.30          1790         702
821223   8B       -9.00  63.0 3259.30          1800         680
821224   8B       -9.00  63.0 3259.20          1700         660
821225   8B       -9.00  63.0 3259.20          1470         560
821226   8B       -9.00  63.0 3259.30          1320         500
821227   8B       -9.00  63.0 3259.60          1450         460
821228   8B       -9.00  63.0 3259.50          1300         430
821229   8B       -9.00  63.0 3259.60          1200         420
821230   8B       -9.00  63.0 3259.70          1250         410
821231   8B       -9.00  63.0 3259.60          1200         410
830101   8B       -9.00  63.0 3259.50          1150         405
830102   8B       -9.00  63.0 3259.50          1150         400
830103   8B       -9.00  63.0 3259.60          1300         440
830104   8B       -9.00  63.0 3259.70          1500         500
830105   8B       -9.00  63.0 3259.40          1800         600
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  DATE    WELL    ELEV    DEPTH   STAGE          CLFQ        BLKQ
 830106    88      -9.00   63.0 3259.50          2200         660
 830107    88      -9.00   63.0 3259.10          2540         720
 830108    88      -9.00   63.0 3258.90          2400         820
 830109    88      -9.00   63.0 3258.90          2730         840
 830110    88      -9.00   63.0 3258.80          2420         820
 830111    88    3247.14   63.0 3258.90          2380         780
 830112    88    3247.06   63.0 3259.00          2290         720
 830113    88    3246.87   63.0 3259.10          2040         700
 830114    88    3246.70   63.0 3258.90          1920         660
 830115    88    3246.50   63.0 3259.00          1680         620
 830115    88    3246.28   63.0 3259.10          1580         605
 830117    88    3246.09   63.0 3259.20          1590         600
 830118    88    3245.94   63.0 3259.30          1630         610
 830119    88    3245.97   63.0 3259.20          1600         610
 830120    88    3246.02   63.0 3259.10          1520         580
 830121    88    3246.00   63.0 3259.20          1530         580
 830122    88    3245.94   63.0 3259.30          1570         590
 830123    88    3245.85   63.0 3259.30          1570         590
 830124    88    3245.73   63.0 3259.20          1530         580
 830125    88    3245.62   63.0 3259.40          1540         580
 830126    88    3245.50   63.0 3259.20          1520         580
 830127    88    3245.36   63.0 3259.20          1530         580
 830128    88    3245.25   63.0 3259.20          1560         580
 830129    88    3245.17   63.0 3259.20          1540         580
 830130    88    3245.06   63.0 3259.00          1480         560
 830131    88    3244.94   63.0 3259.10          1500         540
 830201    88    3244.86   63.0 3259.10          1500         540
 830202    88    3244.80   63.0 3259.10          1480         540
 830203    88    3244.72   63.0 3259.00          1450         540
 830204    88    3244.65   63.0 3259.10          1300         510
 830205    88    3244.55   63.0 3258.80          1170         460
 830206    88    3244.40   63.0 3259.40          1180         450
 830207    88    3244.33   63.0 3259.30          1340         475
 830208    88    3244.34   63.0 3259.20          1430         520
 830209    88    3244.38   63.0 3259.30          1420         530
 830210    88    3244.49   63.0 3259.30          1420         540
 830211    88    3244.58   63.0 3259.30          1410         540
 830212    88    3244.61   63.0 3259.30          1430         550
 830213    88    3244.58   63.0 3259.30          1770         580
 830214    88    3244.59   63.0 3259.20          1930         610
 830215    88    3244.58   63.0 3259.10          1800         649
 830216    88    3244.53   63.0 3259.20          1830         683
 830217    88    3244.50   63.0 3259.00          1870         666
 830218    88    3244.46   63.0 3259.00          1900         660
 830219    88    3244.42   63.0 3259.00          2470         794
 830220    88    3244.49   63.0 3259.00          2580        1030
 830221    88    3244.39   63.0 3258.80          2270         901
 830222    88    3244.25   63.0 3259.20          2110         771
 830223    88    3244.08   63.0 3259.30          2150         766
 830224    88    3243.93   63.0 3259.40          2200         813
 830225    88    3243.81   63.0 3259.40          2210         843
 830226    88    3243.69   63.0 3259.40          2220         848
 830227    88    3243.55   63.0 3259.20          2160         823
 830228    88    3243.33   63.0 3259.00          1980         748
 830301    88    3243.10   63.0 3259.00          1920         719
 830302    88    3242.87   63.0 3259.00          1920         731
 830303    88    3242.70   63.0 3259.00          2150         806
 830304    88    3242.58   63.0 3259.00          2280         884
 830305    88    3242.45   63.0 3259.00          2320         893
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
830306	8B	3242.35	63.0	3258.80	2200	824
830307	8B	3242.22	63.0	3258.90	2100	793
830308	8B	3242.15	63.0	3258.80	2040	768
830309	8B	3242.06	63.0	3258.80	2010	794
830310	8B	3242.00	63.0	3259.10	2170	884
830311	8B	3241.99	63.0	3259.30	2380	978
830312	8B	3242.04	63.0	3259.50	2670	1170
830313	8B	3242.23	63.0	3259.50	2840	1260
830314	8B	3242.35	63.0	3259.50	2800	1250
830315	8B	3242.46	63.0	3259.40	2700	1170
830315	8B	3242.49	63.0	3259.30	2550	1100
830317	8B	3242.50	63.0	3259.20	2420	1050
830318	8B	3242.43	63.0	3259.00	2340	1000
830319	8B	3242.34	63.0	3258.80	2200	932
830320	8B	3242.20	63.0	3258.90	2040	898
830321	8B	3242.09	63.0	3259.10	2060	890
830322	8B	3241.99	63.0	3259.10	2260	884
830323	8B	3241.92	63.0	3259.00	2070	873
830324	8B	3241.82	63.0	3258.80	1990	865
830325	8B	3241.74	63.0	3258.80	1960	852
830326	8B	3241.67	63.0	3258.60	1940	832
830327	8B	3241.60	63.0	3259.10	1870	821
830328	8B	3241.55	63.0	3259.20	1900	823
830329	8B	3241.52	63.0	3259.20	1890	822
830330	8B	3241.48	63.0	3259.20	1900	866
830331	8B	3241.48	63.0	3259.30	1990	906
830401	8B	3241.50	63.0	3259.30	1980	902
830402	8B	3241.51	63.0	3259.30	1970	914
830403	8B	3241.53	63.0	3259.30	1900	927
830404	8B	3241.56	63.0	3259.30	1970	912
830405	8B	3241.55	63.0	3259.30	1920	886
830406	8B	3241.52	63.0	3259.20	1870	873
830407	8B	3241.49	63.0	3258.60	1910	869
830408	8B	3241.45	63.0	3258.90	1850	869
830409	8B	3241.42	63.0	3258.90	1870	870
830410	8B	3241.42	63.0	3258.90	1910	887
830411	8B	3241.42	63.0	3259.30	1900	882
830412	8B	3241.42	63.0	3259.20	1870	871
830413	8B	3241.41	63.0	3259.20	1850	854
830414	8B	3241.39	63.0	3259.10	1810	841
830415	8B	3241.37	63.0	3259.10	1760	834
830416	8B	3241.40	63.0	3259.50	1770	830
830417	8B	3241.43	63.0	3259.40	1780	836
830418	8B	3241.44	63.0	3259.40	1820	868
830419	8B	3241.45	63.0	3259.50	1900	917
830420	8B	3241.50	63.0	3259.50	2030	997
830421	8B	3241.60	63.0	3259.30	2220	1100
830422	8B	3241.73	63.0	3259.60	2410	1230
830423	8B	3241.88	48.1	3259.70	2740	1420
830424	8B	3242.08	63.0	3259.80	3160	1730
830425	8B	3242.32	63.0	3259.60	3880	2130
830426	8B	3242.59	63.0	3259.70	4120	2240
830427	8B	3242.83	63.0	3259.60	3920	2150
830428	8B	3242.98	63.0	3259.40	3720	2030
830429	8B	3243.12	63.0	3259.90	3440	1900
830430	8B	3243.26	63.0	3259.90	3340	1800
830501	8B	3243.42	63.0	3259.60	3260	1730
830502	8B	3243.48	63.0	3259.60	3150	1690
830503	8B	3243.57	63.0	3259.60	3170	1700

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
830504	88	3243.64	63.0	3259.60	3170	1690
830505	88	3243.70	63.0	3259.80	3180	1720
830506	88	3243.77	63.0	3259.70	3600	1930
830507	88	3243.93	63.0	3259.70	3840	2080
830508	88	3243.87	63.0	3259.70	3950	2240
830509	88	3244.00	63.0	3259.70	4230	2390
830510	88	3244.13	63.0	3259.80	4360	2440
830511	88	3244.28	63.0	3259.60	4210	2360
830512	88	3244.36	63.0	3259.80	4070	2230
830513	88	3244.41	63.0	3259.70	3890	2040
830514	88	3244.44	63.0	3259.80	3760	2040
830515	88	3244.47	63.0	3259.80	3770	2010
830516	88	3244.52	63.0	3259.80	3900	2040
830517	88	3244.59	63.0	3259.90	4000	2050
830518	88	3244.68	63.0	3259.80	4130	1990
830519	88	3244.78	63.0	3259.70	4560	2420
830520	88	3244.86	63.0	3259.80	4900	2620
830521	88	3244.98	63.0	3259.80	5130	2830
830522	88	3245.10	63.0	3259.80	5600	3180
830523	88	3245.25	63.0	3259.80	6300	3700
830524	88	3243.41	63.0	3259.80	7160	4360
830525	88	3245.58	63.0	3259.90	8490	5280
830526	88	3245.76	63.0	3260.10	10100	6350
830527	88	3245.95	63.0	3259.70	11700	7150
830528	88	3246.11	63.0	3259.90	12500	7270
830529	88	3246.23	63.0	3260.10	12800	7320
830530	88	3246.57	63.0	3260.10	13300	7550
830531	88	3246.57	63.0	3259.80	12900	7210
830601	88	3246.61	63.0	3259.80	11600	6500
830602	88	3246.55	63.0	3259.70	10200	5810
830603	88	3246.48	63.0	3259.40	9310	5300
830604	88	3246.35	63.0	3259.20	8790	5100
830605	88	3246.21	63.0	3259.00	8460	4940
830606	88	3246.08	63.0	3258.80	8050	4680
830607	88	3245.94	63.0	3258.50	7670	4500
830608	88	3245.83	63.0	3258.40	7490	4470
830609	88	3245.77	63.0	3258.30	7450	4460
830610	88	3245.62	63.0	3258.30	7430	4450
830611	88	3245.53	63.0	3258.20	7420	4410
830612	88	3245.46	63.0	3258.10	7280	4150
830613	88	3245.36	63.0	3257.80	6680	3740
830614	88	3245.23	63.0	3257.00	6000	3370
830615	88	3245.08	63.0	3256.60	5460	3760
830616	88	3244.94	63.0	3256.30	5240	3030
830617	88	3244.81	63.0	3254.80	5120	2890
830618	88	3244.63	63.0	3254.40	5110	2970
830619	88	3244.48	63.0	3254.30	5510	3130
830620	88	3244.33	63.0	3253.90	5150	2900
830621	88	3244.11	63.0	3253.40	4740	2690
830622	88	3243.88	63.0	3252.80	4520	2550
830623	88	3243.68	63.0	3252.30	4180	2350
830624	88	3243.48	63.0	3257.40	3610	2250
830625	88	3243.64	63.0	3259.60	3820	2200
830626	88	3243.96	63.0	3259.50	3790	2140
830627	88	3244.15	63.0	3259.80	3670	2090
830628	88	3244.36	63.0	3260.00	4070	2200
830629	88	3244.67	63.0	3260.10	4550	2370
830630	88	3244.89	63.0	3260.10	4700	2410
830701	88	3245.07	63.0	3259.70	4700	2430

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  DATE    WELL    ELEV    DEPTH  STAGE           CLFQ       BLKQ
 830702    88    3245.10   63.0 3259.70          4540       2410
 830703    88    3245.17   63.0 3259.70          4660       2380
 830704    88    3245.20   63.0 3259.60          4410       2280
 830705    88    3245.20   63.0 3259.80          4080       2140
 830706    88    3245.23   63.0 3259.90          3820       2020
 830707    88    3245.26   63.0 3259.80          3750       1970
 830708    88    3245.25   63.0 3259.70          3590       1900
 830709    88    3245.23   63.0 3259.70          3370       1820
 830710    88    3245.32   63.0 3260.00          4460       2220
 830711    88    3245.66   63.0 3259.80          7410       2920
 830712    88    3245.68   63.0 3259.80          6410       2700
 830713    88    3245.65   63.0 3260.00          5410       2370
 830714    88    3245.65   63.0 3259.60          4920       2190
 830715    88    3245.65   63.0 3260.00          4810       2130
 830716    88    3245.63   63.0 3259.80          4610       2060
 830717    88    3245.60   63.0 3259.80          4400       1970
 830718    88    3245.55   63.0 3259.90          4160       1880
 830719    88    3245.54   63.0 3260.00          4010       1810
 830720    88    3245.53   63.0 3259.90          3850       1750
 830721    88    3245.52   63.0 3259.80          3870       1750
 830722    88    3245.49   63.0 3259.90          3690       1710
 830723    88    3245.48   63.0 3259.90          3500       1610
 830724    88    3245.43   63.0 3259.90          3340       1550
 830725    88    3245.40   63.0 3259.90          3310       1530
 830726    88    3245.35   63.0 3259.90          3200       1510
 830727    88    3245.31   63.0 3259.80          3050       1430
 830728    88    3245.24   63.0 3259.90          2860       1360
 830729    88    3245.20   63.0 3259.90          2780       1300
 830730    88    3245.13   63.0 3259.80          2680       1260
 830731    88    3245.06   63.0 3259.70          2470       1210
 830801    88    3245.08   63.0 3259.70          2610       1210
 830802    88    3244.98   63.0 3259.40          2470       1170
 830803    88    3244.87   63.0 3259.30          2380       1140
 830804    88    3244.76   63.0 3259.20          2310       1130
 830805    88    3244.77   63.0 3259.30          2250       1110
 830806    88    3244.58   63.0 3259.30          2150       1060
 830807    88    3244.49   63.0 3259.30          2040       1010
 830808    88    3244.39   63.0 3259.00          1920        976
 830809    88    3244.30   63.0 3259.20          1900        953
 830810    88    3244.27   63.0 3259.20          1900        952
 830811    88    3244.14   63.0 3259.50          2080       1050
 830812    88    3244.14   63.0 3259.30          2300       1090
 830813    88    3244.09   63.0 3258.60          2220       1020
 830814    88    3244.00   63.0 3257.80          2150        967
 830815    88    3243.86   63.0 3257.90          2010        926
 830816    88    3243.72   63.0 3257.90          2120        913
 830817    88    3243.56   63.0 3256.30          1930        898
 830818    88    3243.24   63.0 3256.20          1860        864
 830819    88    3243.16   63.0 3257.00          1670        828
 830820    88    3243.09   63.0 3258.80          1660        810
 830821    88    3242.35   63.0 3259.10          1790        785
 830822    88    3243.53   63.0 3259.20          1810        806
 830823    88    3243.70   63.0 3259.40          1990        842
 830824    88    3243.86   63.0 3259.40          2080        842
 830825    88    3244.00   63.0 3259.30          2020        817
 830826    88    3244.09   63.0 3258.90          1940        798
 830827    88    3244.15   63.0 3258.90          1940        778
 830828    88    3244.20   63.0 3258.90          1910        764
 830829    88    3244.21   63.0 3258.80          1880        750
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	8LKQ
830830	8B	3244.16	63.0	3258.50	1800	731
830831	88	3244.08	63.0	3259.30	1750	714
830901	8B	3244.10	63.0	3259.10	1770	710
830902	8B	3244.12	63.0	3259.10	1820	722
830903	88	3244.17	63.0	3259.10	1840	712
830904	88	3244.20	63.0	3259.10	1830	714
830905	8B	3244.19	63.0	3259.10	1800	703
830906	8B	3244.13	63.0	3259.00	1770	690
830907	8B	3244.07	63.0	3258.90	1740	682
830908	8B	3243.98	63.0	3258.80	1720	680
830909	8B	3243.85	63.0	3258.50	1710	685
830910	8B	3243.77	63.0	3258.80	1730	687
830911	8B	3243.79	63.0	3259.20	1900	751
830912	8B	3243.89	63.0	3259.10	2010	773
830913	88	3243.95	63.0	3259.10	1980	760
830914	8B	3243.98	63.0	3258.90	1920	729
830915	8B	3243.96	63.0	3258.70	1870	706
830916	8B	3243.90	63.0	3258.50	1850	694
830917	8B	3243.76	63.0	3258.30	1830	679
830918	8B	3243.62	63.0	3257.80	1810	679
830919	88	3243.49	63.0	3258.70	1850	712
830920	88	3243.50	63.0	3258.90	1960	707
830921	8B	3243.55	63.0	3259.00	2020	709
830922	88	3243.62	63.0	3259.10	2060	711
830923	8B	3243.66	63.0	3259.00	2070	704
830924	8B	3243.66	63.0	3259.10	2030	706
830925	88	3243.68	63.0	3259.10	2010	700
830926	88	3243.70	63.0	3259.00	1980	687
830927	8B	3243.64	63.0	3258.50	1950	678
830928	88	3243.50	63.0	3258.20	1910	672
830929	88	3243.38	63.0	3258.30	1890	667
830930	88	3243.29	63.0	3258.60	1890	685
831001	88	3243.31	63.0	3259.00	2010	714
831002	8B	3243.35	63.0	3259.00	2050	715
831003	88	3243.40	63.0	3258.50	2110	719
831004	8B	3243.31	63.0	3258.20	1980	713
831005	88	3243.27	63.0	3259.20	1960	711
831006	8B	3243.30	63.0	3258.20	2050	708
831007	8B	3243.20	63.0	3258.60	1870	701
831008	8B	3243.21	63.0	3258.90	1890	694
831009	88	-9.00	63.0	3258.90	1950	724
831010	88	-9.00	63.0	3258.00	2090	741
831011	8B	-9.00	63.0	3258.10	2120	733
831012	8B	-9.00	63.0	3256.80	2000	712
831013	88	3242.90	63.0	3258.40	1970	708
831014	88	3242.82	63.0	3257.80	1910	714
831015	88	3242.80	63.0	3258.20	2000	708
831016	88	3242.92	63.0	3258.60	2080	707
831017	88	3243.00	63.0	3258.60	2050	702
831018	88	3242.98	63.0	3259.20	2020	705
831019	8B	3243.02	63.0	3258.70	2060	701
831020	8B	3243.02	63.0	3259.10	2000	694
831021	88	3243.04	63.0	3259.00	1980	687
831022	8B	3243.0B	63.0	3258.90	1950	682
831023	8B	3243.10	63.0	3258.90	1940	680
831024	8B	3243.11	63.0	3258.80	1940	674
831025	88	3243.13	63.0	3259.00	1960	677
831026	88	3243.13	63.0	3259.00	1940	680
831027	88	3243.12	63.0	3258.90	1920	680

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
831028	8B	3243.10	63.0	3258.90	1910	680
831029	8B	3243.10	63.0	3258.90	1890	680
831030	8B	3243.09	63.0	3258.80	1890	674
831031	8B	3243.07	63.0	3258.80	1930	672
831101	8B	3242.98	63.0	3257.60	1970	667
831102	8B	3242.83	63.0	3256.50	1950	669
831103	8B	3242.59	63.0	3256.50	1900	669
831104	8B	3242.44	63.0	3256.60	1970	676
831105	8B	3242.23	63.0	3255.00	1990	682
831106	8B	3241.98	63.0	3254.40	1980	694
831107	8B	3241.75	63.0	3254.10	2060	725
831108	8B	3241.51	63.0	3253.30	2130	714
831109	8B	3241.27	63.0	3253.10	2020	698
831110	8B	3241.00	63.0	3253.30	1960	686
831111	8B	3240.76	63.0	3252.80	1990	707
831112	8B	3240.55	63.0	3252.80	2050	718
831113	8B	3240.36	63.0	3252.80	2050	720
831114	8B	3240.17	63.0	3252.50	2030	712
831115	8B	3240.01	63.0	3252.50	2000	701
831116	8B	3239.87	63.0	3252.50	1970	691
831117	8B	3239.70	63.0	3252.40	1960	692
831118	8B	3239.56	63.0	3252.40	1960	698
831119	8B	3239.39	63.0	3252.20	1940	694
831120	8B	3239.24	63.0	3252.20	1920	696
831121	8B	3239.10	63.0	3252.20	1910	701
831122	8B	3238.96	63.0	3252.20	1820	655
831123	8B	3238.83	63.0	3252.50	1660	646
831124	8B	3238.70	63.0	3252.10	1780	681
831125	8B	3238.58	63.0	3252.70	1880	694
831126	8B	3238.46	63.0	3252.50	1850	705
831127	8B	3238.36	63.0	3252.30	1900	720
831128	8B	3238.27	63.0	3252.10	1880	715
831129	8B	3238.19	63.0	3252.30	1790	663
831130	8B	3238.10	63.0	3252.40	1530	540
831201	8B	3238.04	63.0	3252.70	1230	450
831202	8B	3238.04	63.0	3252.80	1200	430
831203	8B	3238.14	63.0	3252.90	1300	500
831204	8B	3238.34	63.0	3253.00	1500	580
831205	8B	3238.73	63.0	3252.60	1450	560
831206	8B	3239.12	63.0	3252.30	1400	540
831207	8B	3239.52	63.0	3252.70	1400	520
831208	8B	3240.19	63.0	3252.20	1500	540
831209	8B	3240.79	63.0	3252.50	1600	600
831210	8B	3241.33	63.0	3252.60	1700	640
831211	8B	3241.81	63.0	3252.60	1750	660
831212	8B	3242.14	63.0	3252.60	1700	650
831213	8B	3242.31	63.0	3252.20	1700	640
831214	8B	3242.34	63.0	3252.40	1700	640
831215	8B	3242.33	63.0	3252.40	1700	630
831216	8B	3242.31	63.0	3252.30	1680	620
831217	8B	3242.23	63.0	3251.30	1350	500
831218	8B	3242.15	63.0	3252.60	920	350
831219	8B	3242.00	63.0	3252.50	980	380
831220	8B	3241.95	63.0	3252.50	1050	400
831221	8B	3242.04	63.0	3252.30	960	380
831222	8B	3242.14	63.0	3252.70	900	350
831223	8B	3242.24	63.0	3252.50	890	330
831224	8B	3242.37	63.0	3252.60	880	330
831225	8B	3242.53	63.0	3252.60	910	350

DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
831226	8B	3242.70	63.0	3253.00	940	360
831227	8B	3242.91	63.0	3252.50	980	370
831228	8B	3243.14	63.0	3252.90	980	360
831229	88	3243.41	63.0	3252.60	940	350
831230	8B	3243.52	63.0	3252.50	1000	370
831231	88	3243.75	63.0	3252.70	1100	420
840101	8B	3243.83	63.0	3252.90	1200	-9
840102	8B	3243.91	63.0	3252.50	1300	-9
840103	8B	3243.58	63.0	3252.70	1350	-9
840104	88	3244.02	63.0	3252.70	1400	-9
840105	8B	3244.09	63.0	3259.30	1500	-9
840106	88	3244.28	63.0	3259.30	1700	-9
840107	88	3244.98	63.0	3259.10	1800	-9
840108	8B	3245.46	63.0	3257.00	1700	-9
840109	8B	3245.51	63.0	3251.40	1650	-9
840110	8B	3245.52	63.0	3254.60	1650	-9
840111	88	3245.38	63.0	3253.50	1700	-9
840112	88	3245.18	63.0	3252.30	1700	-9
840113	88	3244.75	63.0	3252.20	1500	-9
840114	88	3244.44	63.0	3252.60	1300	-9
840115	8B	3244.13	63.0	3251.40	1200	-9
840115	88	3243.75	63.0	3252.10	1200	-9
840117	88	3243.60	63.0	3252.10	1100	-9
840118	88	3243.55	63.0	3251.90	1000	-9
840119	88	3243.58	63.0	3251.80	910	-9
840120	8B	3243.71	63.0	3252.00	960	-9
840121	8B	3243.88	63.0	3251.10	1100	-9
840122	8B	3244.00	63.0	3252.10	1200	-9
840123	8B	3244.04	63.0	3251.90	1600	-9
840124	8B	3244.02	63.0	3252.10	1700	-9
840125	88	3243.98	63.0	3252.10	1900	-9
840126	8B	3243.90	63.0	3252.40	2200	-9
840127	88	3243.86	63.0	3252.60	2300	-9
840128	88	3243.77	63.0	3252.30	2340	-9
840129	8B	3243.63	63.0	3252.60	2200	-9
840130	8B	3243.55	63.0	3252.60	2040	-9
840131	88	3243.23	63.0	3252.50	1870	-9
840201	8B	3243.00	63.0	3252.70	1790	-9
840202	8B	3242.79	63.0	3253.00	1780	-9
840203	88	3242.58	63.0	3253.30	1700	-9
840204	88	3242.39	63.0	3253.50	1690	-9
840205	88	3242.20	63.0	3253.10	1640	-9
840206	8B	3240.00	63.0	3253.50	1630	-9
840207	8B	3241.82	63.0	3253.30	1620	-9
840208	88	3241.66	63.0	3253.40	1610	-9
840209	8B	3241.68	63.0	3255.80	1470	-9
840210	8B	3241.97	63.0	3259.60	1430	-9
840211	88	3242.08	63.0	3258.10	1660	-9
840212	88	3242.16	63.0	3257.90	1560	-9
840213	8B	3242.18	63.0	3256.60	1650	-9
840214	88	3242.30	63.0	3259.20	1660	-9
840215	8B	3242.43	63.0	3258.60	1650	-9
840216	88	3242.58	63.0	3259.80	1600	-9
840217	88	3242.73	63.0	3259.30	1550	-9
840218	88	3242.80	63.0	3259.40	1570	-9
840219	8B	3242.86	63.0	3259.40	1480	-9
840220	88	3242.89	63.0	3259.40	1450	-9
840221	8B	3242.96	63.0	3259.40	1500	-9
840222	8B	3242.98	63.0	3259.30	1510	-9

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 DATE.   WELL    ELEV    DEPTH   STAGE           CLFQ          BLKQ
840223    8B    3243.05   63.0  3259.30          1470            -9
840224    8B    3243.12   63.0  3259.30          1430            -9
840225    8B    3243.16   63.0  3259.20          1450            -9
840226    8B    3243.18   63.0  3259.20          1450            -9
840227    8B    3243.22   63.0  3259.20          1410            -9
840228    8B    3243.27   63.0  3259.30          1400            -9
840229    8B    3243.29   63.0  3259.30          1450            -9
840301    8B    3243.29   63.0  3258.90          1460            -9
840302    8B    3243.28   63.0  3259.30          1470            -9
840303    8B    3243.31   63.0  3259.10          1550            -9
840304    8B    3243.33   63.0  3259.00          1530            -9
840305    8B    3243.33   63.0  3258.70          1500            -9
840306    8B    3243.23   63.0  3258.70          1420            -9
840307    8B    3243.20   63.0  3259.00          1440            -9
840308    8B    3243.21   63.0  3259.10          1490            -9
840309    8B    3243.26   63.0  3259.20          1580            -9
840310    8B    3243.36   63.0  3259.20          1700            -9
840311    8B    3243.48   63.0  3259.30          1760            -9
840312    8B    3243.63   63.0  3259.50          1810            -9
840313    8B    3243.74   63.0  3259.50          1790            -9
840314    8B    3243.80   63.0  3259.60          1880            -9
840315    8B    3243.98   63.0  3259.50          2180            -9
840316    8B    3244.01   63.0  3259.20          2090            -9
840317    8B    3244.03   63.0  3259.30          2030            -9
840318    8B    3244.02   63.0  3259.20          1980            -9
840319    8B    3244.00   63.0  3259.00          1900            -9
840320    8B    3244.04   63.0  3259.60          1830            -9
840321    8B    3244.13   63.0  3259.70          2060            -9
840322    8B    3244.18   63.0  3259.40          2190            -9
840323    8B    3244.21   63.0  3259.30          2120            -9
840324    8B    3244.27   63.0  3259.30          2120            -9
840325    8B    3244.30   63.0  3259.30          2140            -9
840326    8B    3244.37   63.0  3259.30          2160            -9
840327    8B    3244.38   63.0  3259.30          2130            -9
840328    8B    3244.40   63.0  3259.30          2110            -9
840329    8B    3244.42   63.0  3259.20          2080            -9
840330    8B    3244.40   63.0  3259.20          2040            -9
840331    8B    3244.39   63.0  3259.10          2000            -9
840401    8B    3244.36   63.0  3259.10          1970            -9
840402    8B    3244.31   63.0  3259.00          1940            -9
840403    8B    3244.25   63.0  3259.00          1910            -9
840404    8B    3244.21   63.0  3258.90          1890            -9
840405    8B    3244.20   63.0  3259.00          1920            -9
840406    8B    3244.20   63.0  3259.20          2060            -9
840407    8B    3244.26   63.0  3259.30          2200            -9
840408    8B    3244.38   63.0  3259.40          2240            -9
840409    8B    3244.39   63.0  3259.50          2280            -9
840410    8B    3244.48   63.0  3259.50          2330            -9
840411    8B    3244.50   63.0  3259.50          2320            -9
840412    8B    3244.56   63.0  3259.50          2280            -9
840413    8B    3244.57   63.0  3259.60          2240            -9
840414    8B    3244.57   63.0  3259.60          2200            -9
840415    8B    3244.58   63.0  3259.60          2180            -9
840416    8B    3244.59   63.0  3259.60          2370            -9
840417    8B    3244.63   63.0  3260.00          2950            -9
840418    8B    3244.86   63.0  3259.90          3640            -9
840419    8B    3244.98   63.0  3259.70          4550            -9
840420    8B    3244.17   63.0  3259.30          6050            -9
840421    8B    3245.08   63.0  3256.80          6500            -9
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
840422	8B	3244.93	63.0	3256.80	6120	-9
840423	8B	3244.83	63.0	3256.80	6060	-9
840424	8B	3244.74	63.0	3255.40	6090	-9
840425	8B	3244.50	63.0	3257.00	5400	-9
840426	8B	3244.35	63.0	3258.90	4950	-9
840427	8B	3244.40	63.0	3259.40	4690	-9
840428	8B	3244.50	63.0	3259.30	4420	-9
840429	8B	3244.51	63.0	3259.20	4170	-9
840430	8B	3244.49	63.0	3259.30	3950	-9
840501	8B	3244.49	63.0	3259.30	3760	-9
840502	8B	3244.48	63.0	3259.30	3710	-9
840503	8B	3244.47	63.0	3259.20	3650	-9
840504	8B	3244.46	63.0	3259.20	3600	-9
840505	8B	3244.45	63.0	3259.10	3520	-9
840506	8B	3244.36	63.0	3259.00	3400	-9
840507	8B	3244.28	63.0	3259.00	3280	-9
840508	8B	3244.23	63.0	3258.70	3160	-9
840509	8B	3244.14	63.0	3258.80	3190	-9
840510	8B	3244.07	63.0	3259.30	3470	-9
840511	8B	3244.12	63.0	3259.50	3670	-9
840512	8B	3244.18	63.0	3259.60	3800	-9
840513	8B	3244.28	63.0	3260.00	4260	-9
840514	8B	3244.47	63.0	3259.30	5170	-9
840515	8B	3244.53	63.0	3258.80	7650	-9
840516	85	3244.70	63.0	3259.60	11300	-9
840517	8B	3244.88	63.0	3259.50	12300	-9
840518	8B	3244.97	63.0	3259.70	11100	-9
840519	8B	3245.08	63.0	3259.80	10400	-9
840520	8B	3245.16	63.0	3259.90	10600	-9
840524	8B	3245.18	63.0	3259.70	10200	-9
840525	8B	3245.20	63.0	3259.50	9500	-9
840526	8B	3245.18	63.0	3259.00	8660	-9
840527	8B	3245.05	63.0	3258.80	8230	-9
840528	8B	3244.97	63.0	3258.60	7860	-9
840529	8B	3244.67	63.0	3258.50	7590	-9
840530	8B	3244.63	63.0	3259.10	8100	-9
840531	8B	3244.77	63.0	3259.80	10800	-9
840601	8B	3245.03	63.0	3259.40	12000	-9
840602	8B	3245.17	63.0	3259.50	10500	-9
840603	8B	3245.25	63.0	3259.40	9350	-9
840604	8B	3245.28	-9.0	3259.20	8750	-9
840605	8B	3245.24	-9.0	3259.30	8800	-9
840606	8B	3245.27	63.0	3259.30	9060	-9
840607	8B	3245.26	63.0	3259.10	8760	-9
840608	8B	3245.18	63.0	3258.80	-9	-9
840609	8B	3245.08	63.0	3258.60	-9	-9
840610	8B	3244.96	63.0	3258.30	-9	-9
840611	8B	3244.83	63.0	3258.10	-9	-9
840612	8B	3244.77	63.0	3259.20	-9	-9
840613	8B	3244.80	63.0	3259.20	-9	-9
840614	8B	3244.87	63.0	3259.40	-9	-9
840615	8B	3244.99	63.0	3259.60	-9	-9
840616	8B	3245.14	63.0	3259.80	-9	-9
840617	8B	3245.18	63.0	3259.60	-9	-9
840618	8B	3245.38	63.0	3259.60	-9	-9
840619	8B	3245.45	63.0	3259.40	-9	-9
840620	8B	3245.46	63.0	3259.30	-9	-9
840621	8B	3245.47	63.0	3259.80	-9	-9
840622	8B	3245.66	63.0	3259.60	-9	-9

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 DATE    WELL   ELEV    DEPTH   STAGE         CLFQ      BLKQ
840623   88    3245.82   63.0  3253.30          -9        -9
840624   88    3245.91   63.0  3253.50          -9        -9
840625   88    3245.91   -9.0  3253.30          -9        -9
840626   88    3245.88   63.0  3253.50          -9        -9
840627   88    3245.87   63.0  3259.20          -9        -9
840628   88    3245.86   63.0  3258.00          -9        -9
840629   88    3245.72   63.0  3258.60          -9        -9
840630   88    3245.63   -9.0  3258.40          -9        -9
820303   9     3246.05   62.0  3259.70        2400       815
820319   9     3244.58   62.0  3259.60        2280       902
830906   9     3243.61   62.0  3259.00        1770       690
831122   9     3239.25   62.0  3252.20        1820       655
820222   10    3247.76   90.0  3259.90        5630      1390
820308   10    3245.84   90.0  3259.30        2040       726
820310   10    3247.48   90.0  3259.90        2690      1070
820312   10    3245.28   90.0  3259.70        3110      1320
820315   10    3245.08   90.0  3259.80        2710      1100
820317   10    3245.00   90.0  3259.80        2500      1010
820319   10    3244.94   90.0  3259.60        2280       902
820324   10    3244.55   90.0  3259.60        2200       903
820409   10    3242.98   90.0  3258.90        2080       880
820415   10    3243.62   90.0  3259.30        4740      2220
820421   10    3243.87   90.0  3259.80        3340      1690
820427   10    3243.87   90.0  3259.70        6060      3260
820504   10    3244.54   90.0  3259.80        9060      4850
820510   10    3245.09   90.0  3259.40        7350      4110
820524   10    3242.61   90.0  3259.70       14100      8280
820601   10    3247.15   90.0  3258.10       10900      5520
820608   10    3246.36   90.0  3257.90       10600      5760
820623   10    3247.11   90.0  3259.60       15300      8200
820629   10    3246.29   90.0  3259.20       13900      6910
820708   10    3245.56   90.0  3256.30        7780      4060
820713   10    3244.76   90.0  3255.60        6070      3080
820716   10    3245.20   90.0  3253.90        6010      2890
820719   10    3243.84   90.0  3253.50        5140      2550
820727   10    3240.06   90.0  3252.50        3520      1710
820806   10    3240.87   90.0  3258.60        2390      1270
820823   10    3241.65   90.0  3259.10        1690       894
820908   10    3251.66   90.0  3259.30        1510       716
820924   10    3243.04   90.0  3259.10        1870       731
821001   10    3243.81   90.0  3259.40        2430       823
821008   10    3243.78   90.0  3259.40        2350       796
821021   10    3243.91   90.0  3259.20        2100       755
821115   10    3243.21   90.0  3259.30        1590       590
830120   10    3245.66   90.0  3259.10        1520       580
830128   10    3244.91   90.0  3259.20        1560       580
830207   10    3243.97   90.0  3259.30        1340       475
830215   10    3244.24   90.0  3259.10        1600       649
830223   10    3243.78   90.0  3259.30        2150       766
830302   10    3242.57   90.0  3259.00        1920       731
830309   10    3241.57   90.0  3258.80        2010       794
830317   10    3242.01   90.0  3259.20        2420      1050
830323   10    3241.48   90.0  3259.00        2070       873
830331   10    3240.11   90.0  3259.30        1990       906
830408   10    3240.90   90.0  3258.90        1850       869
830417   10    3237.84   90.0  3259.40        1780       836
830423   10    3240.77   90.0  3259.70        2740      1420
830507   10    3242.97   90.0  3259.70        3840      2080
830517   10    3244.15   90.0  3259.90        4000      2050
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 DATE    WELL    ELEV    DEPTH   STAGE          CLFQ       BLKQ
830524    10   3244.83    90.0  3259.80         7160       4360
830601    10   3245.31    90.0  3259.80        11600       6500
830608    10   3245.58    90.0  3258.40         7490       4470
830614    10   3244.62    90.0  3257.00         6000       3370
830623    10   3243.54    90.0  3252.30         4180       2350
830701    10   3244.56    90.0  3259.70         4700       2430
830708    10   3244.86    90.0  3259.70         3590       1900
830720    10   3245.20    90.0  3259.90         3850       1750
830729    10   3244.86    90.0  3259.90         2780       1300
830805    10   3243.34    90.0  3259.30         2250       1110
830906    10   3243.33    90.0  3259.00         1770        690
830921    10   3243.22    90.0  3259.00         2020        709
831103    10   3242.34    90.0  3256.50         1900        669
831123    10   3238.78    90.0  3252.50         1660        646
820303    11   3252.40    55.0  3259.70         2400        815
820319    11   3251.20    55.0  3259.60         2280        902
830906    11   3250.51    55.0  3259.00         1770        690
831201    11   3247.11    55.0  3252.70         1230        450
820227    17   3248.55    96.0  3259.50         2450        887
820308    17   3246.54    96.0  3259.30         2040        726
820319    17   3245.97    96.0  3259.60         2280        902
830906    17   3268.95    96.0  3259.00         1770        690
831123    17   3240.15    96.0  3252.50         1660        646
831201    17   3239.39    96.0  3252.70         1230        450
820226    18   3242.46    71.5  3259.60         2560        927
820308    18   3245.24    71.5  3259.30         2040        726
831122    18   3233.93    71.5  3252.20         1820        655
820227    19   3248.39    80.0  3259.50         2450        887
820308    19   3245.56    80.0  3259.30         2040        726
820319    19   3244.89    80.0  3259.60         2280        902
830906    19   3243.50    80.0  3259.00         1770        690
831122    19   3239.05    80.0  3252.20         1820        655
820305    20   3256.26    70.0  3259.50         2230        777
820319    20   3255.90    70.0  3259.60         2280        902
830907    20   3255.04    70.0  3258.90         1740        682
831123    20   3252.46    70.0  3252.50         1660        646
820305    21   3254.92    86.0  3259.50         2230        777
830907    21   3253.71    86.0  3258.90         1740        682
831123    21   3250.97    86.0  3252.50         1660        646
820305    22   3254.83    90.0  3259.50         2230        777
820310    23   3261.58    53.5  3259.90         2690       1070
820310    24   3263.59    64.7  3259.90         2690       1070
820312    25   3252.60    91.0  3259.70         3110       1320
830907    25   3251.69    91.0  3258.90         1740        682
831123    25   3245.15    91.0  3252.50         1660        646
820312    26   3252.55    83.0  3259.70         3110       1320
820312    27   3252.33    82.0  3259.70         3110       1320
820319    27   3252.08    82.0  3259.60         2280        902
830907    27   3251.28    82.0  3258.90         1740        682
831123    27   3247.81    82.0  3252.50         1660        646
820312    28   3251.87    74.5  3259.70         3110       1320
831123    28   3247.35    28.0  3252.50         1660        646
820409    29   3251.40   125.0  3258.90         2080        880
830906    29   3249.50   125.0  3259.00         1770        690
831123    29   3247.70   125.0  3252.50         1660        646
820409    30   3243.80    95.0  3258.90         2080        880
830906    30   3243.80    95.0  3259.00         1770        690
831123    30   3240.30    95.0  3252.50         1660        646
820409    31   3243.50   108.0  3258.90         2080        880
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 DATE    WELL   ELEV    DEPTH  STAGE         CLFQ      BLKQ
820409   32    3248.00   92.0 3258.90        2080       880
831123   32    3244.20   92.0 3252.50        1660       646
831103   100A  3241.64   59.0 3256.50        1900       669
831121   100A  3238.60   59.0 3252.20        1910       701
840625   100A  3245.84   59.0 3253.30          -9        -9
831021   101A  3213.86   60.4 3259.00        1980       687
831103   101A  3224.63   60.4 3256.50        1900       669
831121   101A  3236.25   60.4 3252.20        1910       701
830408   101B  3242.04   35.0 3258.90        1850       869
830417   101B  3241.71   35.0 3259.40        1780       836
830423   101B  3241.87   35.0 3259.70        2740      1420
830508   101B  3243.72   35.0 3259.70        3950      2240
830517   101B  3244.51   35.0 3259.90        4000      2050
830601   101B  3246.23   35.0 3259.80       11600      6500
830608   101B  3245.54   35.0 3258.40        7490      4470
830614   101B  3244.86   35.0 3257.00        6000      3370
830712   101B  3245.39   35.0 3259.80        6410      2700
830811   101B  3243.89   35.0 3259.50        2080      1050
830816   101B  3243.66   35.0 3257.90        2120       913
830907   101B  3243.68   35.0 3258.90        1740       682
830921   101B  3243.29   35.0 3259.00        2020       709
831021   101B  3242.99   35.0 3259.00        1980       687
831103   101B  3242.59   35.0 3256.50        1900       669
831123   101B  3240.36   35.0 3252.50        1660       646
840127   101B  3243.85   35.0 3252.60        2300        -9
840221   101B  3243.43   35.0 3259.40        1500        -9
840321   101B  3244.39   35.0 3259.70        2060        -9
840503   101B  3244.56   35.0 3259.20        3650        -9
840529   101B  3245.33   35.0 3258.50        7590        -9
840625   101B  3246.29   35.0 3253.30          -9        -9
831103   102A  3245.41   61.5 3256.50        1900       669
831121   102A  3243.72   61.5 3252.20        1910       701
831103   102B  3245.46   49.0 3256.50        1900       669
831121   102B  3243.77   49.0 3252.20        1910       701
840127   102B  3246.25   49.0 3252.60        2300        -9
840221   102B  3245.24   49.0 3259.40        1500        -9
840321   102B  3247.07   49.0 3259.70        2060        -9
840503   102B  3247.33   49.0 3259.20        3650        -9
840529   102B  3241.36   49.0 3258.50        7590        -9
840626   102B  3248.59   49.0 3253.50          -9        -9
831103   103A  3246.30   89.5 3256.50        1900       669
831121   103A  3244.62   89.5 3252.20        1910       701
840625   103A  3248.87   89.5 3253.30          -9        -9
831103   103B  3246.70   75.3 3256.50        1900       669
831121   103B  3245.03   75.3 3252.20        1910       701
840320   103B  3247.78   75.3 3259.60        1830        -9
840503   103B  3247.95   75.3 3259.20        3650        -9
840625   103B  3249.15   75.3 3253.30          -9        -9
831121   104A  3240.61  100.8 3252.20        1910       701
840626   104A  3245.31  100.8 3253.50          -9        -9
831121   104B  3240.11   84.8 3252.20        1910       701
840126   104B  3244.73   84.7 3252.40        2200        -9
840221   104B  3243.71   84.7 3259.40        1500        -9
840320   104B  3244.85   84.7 3259.60        1830        -9
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840503     104B 3245.23   84.7 3259.20      3650    -9
840529     104B 3246.07   84.7 3258.50      7590    -9
840626     104B 3247.15   84.8 3253.50        -9    -9
831103     105A 3242.28  124.0 3256.50      1900   669
831121     105A 3238.59  124.0 3252.20      1910   701
840625     105A 3245.81  124.0 3253.30        -9    -9
831121     105B 3238.56   94.0 3252.20      1910   701
840126     105B 3238.55   94.0 3252.40      2200    -9
840221     105B 3239.32   94.0 3259.40      1500    -9
840320     105B 3243.32   94.0 3259.60      1830    -9
840503     105B 3243.80   94.0 3259.20      3650    -9
840529     105B 3244.51   94.0 3258.50      7590    -9
840625     105B 3245.76   94.0 3253.30        -9    -9
831121     105C 3238.46   72.0 3252.20      1910   701
840625     105C 3245.88   72.0 3253.30        -9    -9
831121     106A 3237.77  124.0 3252.20      1910   701
840130     106A 3242.06  124.0 3252.60      2040    -9
840223     106A 3241.65  124.0 3259.30      1470    -9
840320     106A 3242.58  124.0 3259.60      1830    -9
840503     106A 3243.00  124.0 3259.20      3650    -9
840529     106A 3243.68  124.0 3258.50      7590    -9
840625     106A 3244.57  124.0 3253.30        -9    -9
831121     106B 3238.11  105.0 3252.20      1910   701
840625     106B 3245.33  105.0 3253.30        -9    -9
831121     106C 3237.99   74.0 3252.20      1910   701
840130     106C 3242.22   74.0 3252.60      2040    -9
840221     106C 3241.76   74.0 3259.40      1500    -9
840320     106C 3242.76   74.0 3259.60      1830    -9
840503     106C 3243.17   74.0 3259.20      3650    -9
840529     106C 3243.90   74.0 3258.50      7590    -9
840625     106C 3245.07   74.0 3253.30        -9    -9
831103     107A 3241.33   93.3 3256.50      1900   669
831121     107A 3238.20   93.3 3252.20      1910   701
840320     107A 3243.05   93.3 3259.60      1830    -9
840503     107A 3243.49   93.3 3259.20      3650    -9
840625     107A 3245.44   93.3 3253.30        -9    -9
831103     107B 3241.55  121.0 3256.50      1900   669
831121     107B 3238.47  121.0 3252.20      1910   701
840625     107B 3245.52  121.0 3253.30        -9    -9
831103     107C 3241.64   71.0 3256.50      1900   669
831121     107C 3238.47   71.0 3252.20      1910   701
840320     107C 3243.32   71.0 3259.60      1830    -9
840503     107C 3243.77   71.0 3259.20      3650    -9
840625     107C 3245.69   71.0 3253.30        -9    -9
831121     108A 3234.72   96.0 3252.20      1910   701
840625     108A 3241.57   96.0 3253.30        -9    -9
831121     108B 3234.65   46.8 3252.20      1910   701
840320     108B 3239.15   46.8 3259.60      1830    -9
840625     108B 3241.40   46.8 3253.30        -9    -9
831121     109A 3236.51  134.8 3252.20      1910   701
840625     109A 3235.62  134.8 3253.30        -9    -9
831121     109B 3231.14  100.0 3252.20      1910   701
840126     109B 3242.61  100.0 3252.40      2200    -9
840221     109B 3241.75  100.0 3259.40      1500    -9
840320     109B 3242.71  100.0 3259.60      1830    -9
840503     109B 3243.18  100.0 3259.20      3650    -9
840529     109B 3243.85  100.0 3258.50      7590    -9
840625     109B 3245.02  100.0 3253.30        -9    -9
831121     110A 3250.36  136.0 3252.20      1910   701
840320     110A 3253.48  136.0 3259.60      1830    -9
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DATE	WELL	ELEV	DEPTH	STAGE	CLFQ	BLKQ
840626	110A	3257.76	136.0	3253.50	-9	-9
831121	110B	3250.18	70.6	3252.20	1910	701
840320	110B	3253.18	70.6	3259.60	1830	-9
840626	110B	3254.40	70.6	3253.50	-9	-9
831121	111A	3240.42	143.0	3252.20	1910	701
840321	111A	3245.37	143.0	3259.70	2060	-9
840626	111A	3247.62	143.0	3253.50	-9	-9
831121	111B	3241.15	89.0	3252.20	1910	701
840321	111B	3246.16	89.0	3259.70	2060	-9
840626	111B	3248.48	89.0	3253.50	-9	-9
830909	114	3256.33	9.1	3258.50	1710	685
830922	114	3256.88	9.1	3259.10	2060	711
831103	114	3255.67	9.1	3256.50	1900	669
831121	114	3253.32	9.1	3252.20	1910	701
830909	115	3256.03	9.5	3258.50	1710	685
830922	115	3256.75	9.5	3259.10	2060	711
831103	115	3256.80	9.5	3256.50	1900	669
831121	115	3256.20	9.5	3252.20	1910	701
830909	116	3255.37	10.2	3258.50	1710	685
830922	116	3256.02	10.2	3259.10	2060	711
831103	116	3255.94	10.2	3256.50	1900	669
831121	116	3256.55	10.2	3252.20	1910	701
831103	117	3256.36	-9.0	3256.50	1900	669
831121	117	3254.64	-9.0	3252.20	1910	701
831121	118A	3251.30	10.6	3252.20	1910	701
831121	118B	3253.51	-9.0	3252.20	1910	701
831121	118C	3255.56	-9.0	3252.20	1910	701
831114	119A	3250.83	12.0	3252.50	2030	712
831121	119A	3250.46	12.0	3252.20	1910	701
831114	119B	253.50	7.7	3252.50	2030	712
831121	119B	3254.45	7.7	3252.20	1910	701
831114	119C	3254.42	2.1	3252.50	2030	712
831121	119C	3255.66	2.1	3252.20	1910	701
831114	120	3257.43	-9.0	3252.50	2030	712
831121	120	3256.77	-9.0	3252.20	1910	701
831114	121A	3251.13	10.9	3252.50	2030	712
831121	121A	3250.74	10.9	3252.20	1910	701
840127	121A	3252.94	13.5	3252.60	2300	-9
840223	121A	3255.54	13.5	3259.30	1470	-9
840321	121A	3255.84	13.5	3259.70	2060	-9
840427	121A	3253.64	13.5	3259.40	4690	-9
840531	121A	3255.34	13.5	3259.80	10800	-9
840626	121A	3241.97	13.5	3253.50	-9	-9
831114	121B	3256.87	-9.0	3252.50	2030	712
831121	121B	3256.56	-9.0	3252.20	1910	701
840127	121B	3256.68	7.0	3252.60	2300	-9
840223	121B	3257.38	7.0	3259.30	1470	-9
840321	121B	3257.97	7.0	3259.70	2060	-9
840427	121B	3256.91	7.0	3259.40	4690	-9
831114	121C	3259.37	-9.0	3252.50	2030	712
831121	121C	3257.06	-9.0	3252.20	1910	701
831114	122A	3252.63	12.1	3252.50	2030	712
831121	122A	3251.76	12.1	3252.20	1910	701
840127	122A	3252.84	14.4	3252.60	2300	-9
840223	122A	3254.71	14.4	3259.30	1470	-9
840321	122A	3255.16	14.4	3259.70	2060	-9
840427	122A	3249.00	14.4	3259.40	4690	-9
840531	122A	3255.55	14.4	3259.80	10800	-9
840626	122A	3255.92	14.4	3253.50	-9	-9

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  DATE     WELL   ELEV    DEPTH  STAGE           CLFQ         BLKQ
 831114    1228 3257.64    5.4  3252.50          2030          712
 831121    1228 3257.31    5.4  3252.20          1910          701
 840127    122B 3257.75    7.0  3252.60          2300           -9
 840223    122B 3258.13    7.0  3259.30          1470           -9
 840321    1228 3258.19    7.0  3259.70          2060           -9
 840427    122B 3258.32    7.0  3259.40          4690           -9
 840531    122B 3258.25    7.0  3259.80         10800           -9
 840626    1228 3258.11    7.0  3253.50            -9           -9
 831114    122C 3257.99    1.7  3252.50          2030          712
 831121    122C 3257.70    1.7  3252.20          1910          701
 840127    123A 3251.15   13.1  3252.60          2300           -9
 840223    123A 3252.53   13.1  3259.30          1470           -9
 840321    123A 3252.64   13.1  3259.70          2060           -9
 840427    123A 3251.87   13.1  3259.40          4690           -9
 840531    123A 3253.02   13.1  3259.80         10800           -9
 840626    123A 3253.55   13.1  3253.50            -9           -9
 840127    123B 3256.31    7.5  3252.60          2300           -9
 840223    1238 3257.05    7.5  3259.30          1470           -9
 840321    1238 3257.32    7.5  3259.70          2060           -9
 840427    123B 3257.52    7.5  3259.40          4690           -9
 840531    123B 3257.60    7.5  3259.80         10800           -9
 840626    123B 3257.60    7.5  3253.50            -9           -9
```

APPENDIX F

Quality Assurance Information and Data

Table F1. Average metal concentrations in blanks.

Matrix	As	Cd	Cu	Fe	Mn	Ni	Pb	Zn
well water	2.1 (n = 15)	-	7.7 (n = 6)	11.6 (n = 13)	9.4 (n = 15)	-	1.7 (n = 6)	7.7 (n = 13)
acetic acid (n=9)(grabs)	1.7	0.0	0.0	1 ppm	0.0	5	0.2	46
acetic acid (n=8)(grabs)	0.1	0.4	12.7	3.2	1.8	10	0.0	29
$LiBO_2$ Fusion (n=12)	-	-	-	46	20	-	-	20
Aqua Regia Digestion (n=10)	5	1.2	10	-	-	-	8	-

Note: All values are ppb
Blanks for carbon analyses were all below 0.01% (n=3)

Table F-2

Average % Bias for Certified Standards of Trace Metals in Water

Element	Ave. % Bias-EVST Lab (5 stds)	Ave. % Bias-RMA Lab (2 stds)
As	16.4	10.5
Cd	20.2	11.3
Cu	20.4	2.8
Fe	14.9	7.9
Mn	13.7	5.5
Ni	21.5	4.4
Pb	18.2	3.5
Zn	16.4	3.6

Table F-3

Accuracy of Lithium Metaborate Fusions for Manganese Zinc and Iron

Element	Sample	NBS Certified Value	Mean Meas. Conc.	RSD	Mean % Recovery
Mn	Esturine sediment- SRM 1646 (n=8)	375 ± 20ug/g	359.6 ug/g	6.48%	95.89
Mn	River sediment- SRM 1645 (n=8)	785 ± 97ug/g	831.1 ug/g	5.4%	106
Zn	Esturine sediment	138 ± 6 ug/g	114 ug/g	13.2%	82.6
Zn	River sediment	1720 ± 170ug/g	1577.5 ug/g	3.87%	91.7
Fe	Esturine sediment	33,500 ± 1000ug/g	30,112 ug/g	2.21%	89.89
Fe	River sediment	113,000 ± 12,000 ug/g	92,650 ug/g	20.48%	81.99

**From National Bureau of Standards Certificates of Analysis for Esturine and River Sediment (1982 & 1978, respectively).

Table F-4

Accuracy of Aqua Regia Digestion of NBS Esturine Sediment Standard, SRM 1646

Element	$\overline{X}$ (n)	RSD	Certified Value (ug/g)	Average % Bias
As	24.11 (n=9)	9.38%	11.6 ± 1.3	+108
Cd	1.69 (n=10)	11.83%	0.36 ± 0.07	+369
Cu	12.0 (n=10)	12.4%	18 ± 3	-33.3
Pb	18.78	8.31%	28.2 ± 1.8	-33.5

** National Bureau of Standards, 1982, Certificate of Analysis, Standard Reference Material 1646, Esturine Sediment.

Table F-5

Summary of % Recovery from Spiked Samples

Element	Sample Type (Lab)	% Recovery	(n)
As	Well water (EVST)	94.59	(n=30)
	Well water (RMA)	95.50	(n=6)
	Acetic acid extract (EVST)	96.68	(n=12)
	Aqua regia extract (RMA)	93.88	(n=8)
Cd	Pore water (EVST)	87.43	(n=3)
	Acetic acid extract (EVST)	102.33	(n=6)
	Aqua regia extract (RMA)	103.60	(n=8)
Cu	Well water (EVST)	98.32	(n=9)
	Pore water (EVST)	95.67	(n=3)
	Acetic Acid extract (EVST)	99.61	(n=9)
	Aqua regia extract (RMA)	98.67	(n=3)
Fe	Well water (EVST)	105.93	(n=27)
	Well water (RMA)	98.80	(n=5)
	Acetic acid extract (EVST)	88.97	(n=6)
	Lithium metaborate fusion (NETL)	100.74	(n=27)
Pb	Well water (EVST)	83.67	(n=3)
	Pore water (EVST)	66.63	(n=3)
	Acetic acid extract (EVST)	100.1	(n=6)
	Aqua regia extract (RMA)	89.71	(n=7)
Mn	Well water (EVST)	106.8	(n=27)
	Well water (RMA)	97.20	(n=5)
	Pore water (EVST)	96.23	(n=3)
	Acetic acid extract (EVST)	90.33	(n=12)
	Lithium metaborate fusion (NETL)	101.4	(n=27)
Ni	Pore water (EVST)	102.82	(n=6)
	Acetic acid extract (EVST)	128.14	(n=8)
Zn	Well water (EVST)	102.82	(n=21)
	Well water (RMA)	96.17	(n=6)
	Pore water (EVST)	107.23	(n=3)
	Acetic acid extract (EVST)	109.20	(n=9)
	Lithium metaborate fusion (NETL)	99.58	(n=26)

EVST = Gordon Environemntal Studies Laboratory

RMA = Rocky Mountain Analytical Laboratory

NETL = Northern Engineering and Testing Laboratory

Table F-6

Summary of Replicate Analyses Done by Analytical Labs

Element	Sample Type (Lab)	Ave. % Diff. from Mean	Ave. RSD %
As	Well water (EVST)*	5.48**	6.23
	Well water (RMA)	0.67	---
	Acetic acid extract (EVST)	4.92	5.15
	Aqua regia extract (RMA)	4.89	---
Cd	Pore water (EVST)	3.6	10.5
	Acetic acid extract (EVST)	1.25	4.05
	Aqua regia extract (EVST)	2.67	---
Cu	Well water (EVST)	0.7	---
	Pore water (EVST)	1.74	8.34
	Acetic acid extract (EVST)	2.09	1.55
	Aqua regia extract (RMA)	0.77	---
Fe	Well water (EVST)	7.3	9.38
	Well water (RMA)	1.83	---
	Pore water (EVST)	4.9	11.6
	Acetic acid extract (EVST)	0.73	0.83
	Lithium metaborate fusion (NETL)	0.73	---
Pb	Well water (EVST)	10.5	25.6
	Pore water (EVST)	9.25	28.5
	Acetic acid extract (EVST)	1.92	2.24
	Aqua regia extract (RMA)	1.68	---
Mn	Well water (EVST)	9.99	9.1
	Well water (RMA)	1.76	---
	Pore water (EVST)	0.53	0.51
	Acetic acid extract (EVST)	1.4	1.15
	Lithium metaborate fusion (NETL)	2.16	---
Ni	Pore water (EVST)	1.68	12.78
	Acetic acid extract (EVST)	5.07	30.2
Zn	Well water (EVST)	1.27	2.58
	Well water (RMA)	1.92	---
	Pore water (EVST)	0.47	1.1
	Acetic acid extract (EVST)	2.49	1.01
	Lithium metaborate fusion (NETL)	1.01	---

* EVST = Gordon Environmental Studies Laboratory
RMA = Rocky Mountain Analytical Laboratory
NETL = Northern Engineering and Testing Laboratory

** EVST results are averages of absorbance values; all others are averages of concentration reported as mg/l.

Table F-7

Summary of Precision of Duplicate Water Samples and Sediment Extractions

Type of Preparation	As	Cd	Cu	Fe	Pb	Mn	Zn	Ni	% Org C
	Average % difference from mean								
Acetic acid extract	7.3 (n=14)	6.3 (n=15)	5.0 (n=13)	6.5 (n=16)	8.5 (n=15)	3.9 (n=16)	11.1 (n=16)	16.8 (n=7)	
Lithium metaborate Fusion	---	---	---	7.7 (n=14)	---	7.4 (n=14)	8.0 (n=14)	---	
Aqua regia Digestions	14.36 (n=10)	3.52 (n=10)	2.30 (n=10)	---	2.65 (n=10)	---	---	---	
Well water	4.13 (n=10)	---	1.80 (n=4)	29.64 (n=9)	0.0 (n=5)	5.8 (n=8)	2.69 (n=8)	---	1.30 (n=16)

Table F-8. Summary of precision for $HCl:HNO_3$ digestions.

Element	# hours of digestion	$\overline{X}$ conc. in ug/g	RSD
Cd	1	4.00*	5.77%
	2	3.80	1.57%
	3	3.80	6.96%
	4	3.70	4.68%
	5	3.40	11.76%
As	1	49.33	4.68%
	2	48.00	2.08%
	3	48.33	2.39%
	4	47.33	6.45%
	5	41.33	9.78%
Cu	1	345.33	0.44%
	2	352.00	6.42%
	3	337.00	4.12%
	4	324.67	3.61%
	5	299.67	2.50%
Pb	1	55.33	2.09%
	2	5y.00	3.09%
	3	55.00	5.45%
	4	52.67	2.19%
	5	49.00	2.04%

* n = 3 for all digestion times.

Table F-9. Analysis of lithium metaborate fusion split samples.

Sample	n	Element	Mean	RSD
MSC5L	3	Fe	51.50	2.67%
MSG30A	3	Fe	62.13	1.71%
MSC5L	3	Mn	2.83	3.89%
MSG30A	3	Mn	11.67	3.96%
MSC5L	3	Zn	3.29	1.03%
MSG30A	3	An	5.55	1.75%

APPENDIX G

Sediment Geochemistry Data

Histograms of Total Metals in Grab Samples

Figure G1

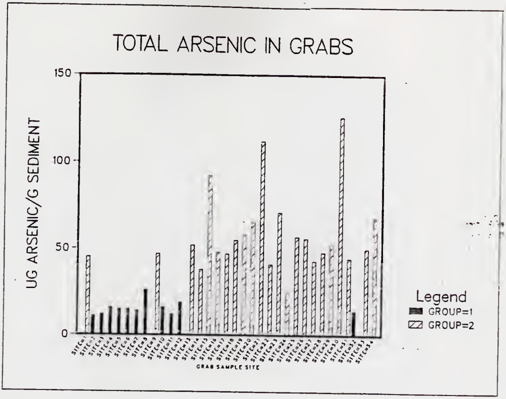


Figure G2

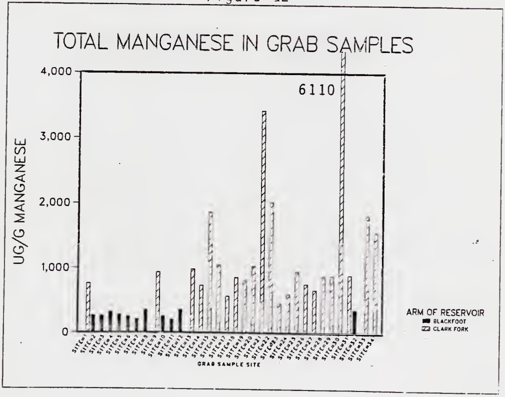


Figure G3

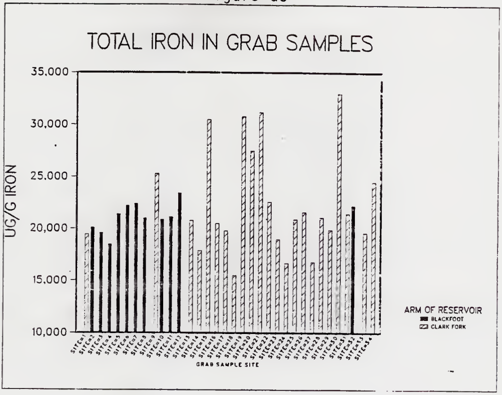


Figure G4

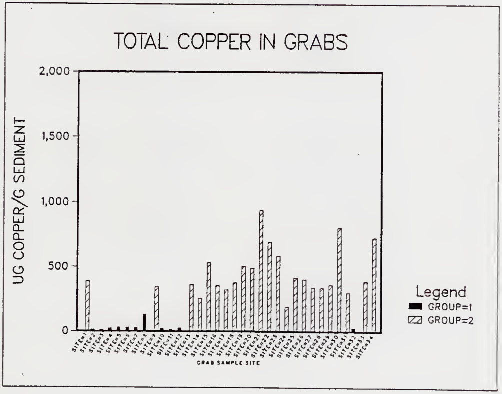


Figure G5

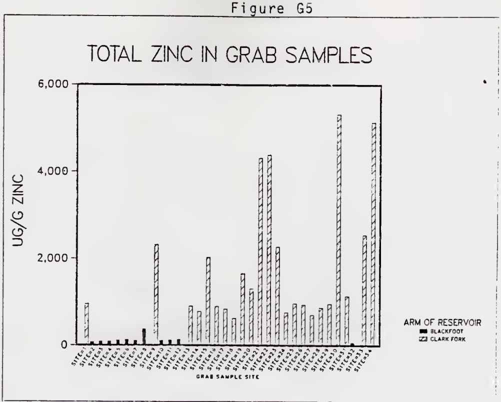


Figure G6

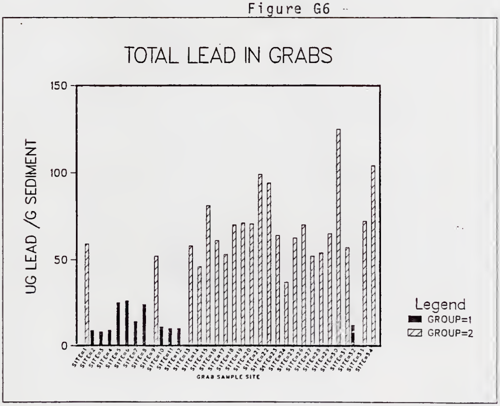
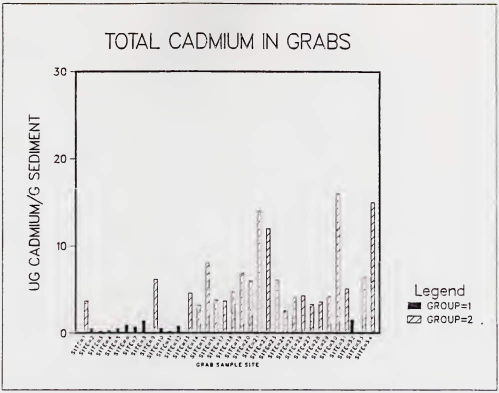


Figure G7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UG CADMIUM/G SEDIMENT
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20
10
0
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SITE=2
SITE=3
SITE=4
SITE=5
SITE=6
SITE=7
SITE=8
SITE=9
SITE=10
SITE=11
SITE=12
SITE=13
SITE=14
SITE=15
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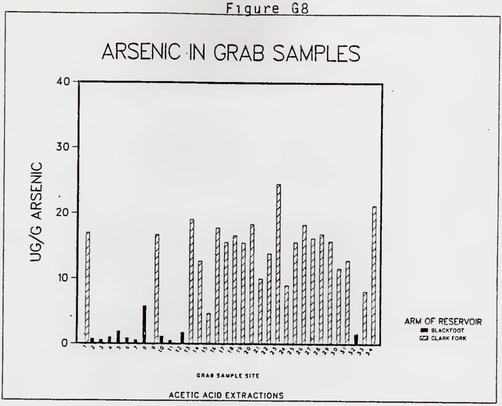
SITE=24
SITE=25
SITE=26
SITE=27
SITE=28
SITE=29
SITE=30
SITE=31
SITE=32
SITE=33
SITE=34
GRAB SAMPLE SITE
Legend
■ GROUP=1
▨ GROUP=2

Histograms of Acetic Acid Extractable Metals in Grab Samples

Figure G8



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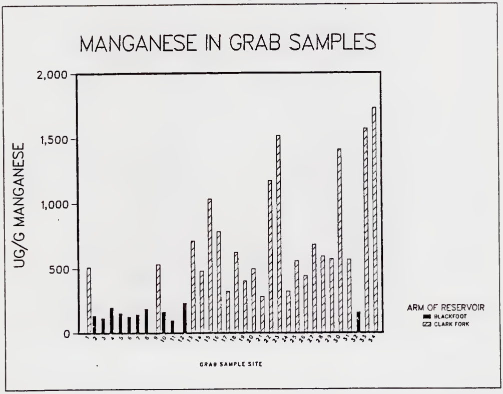


Figure G10

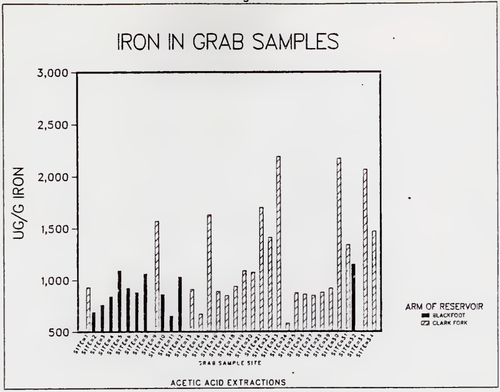


Figure G11

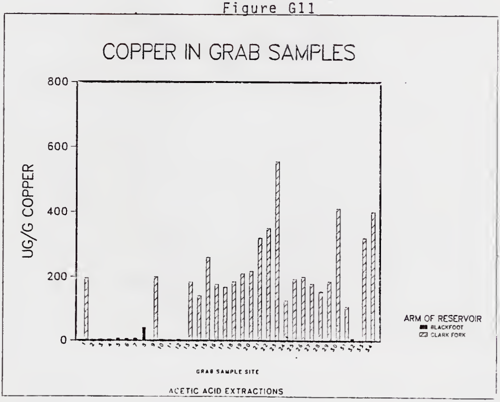


Figure G12

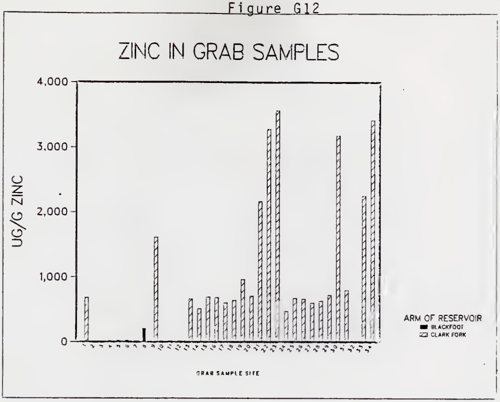


Figure G13

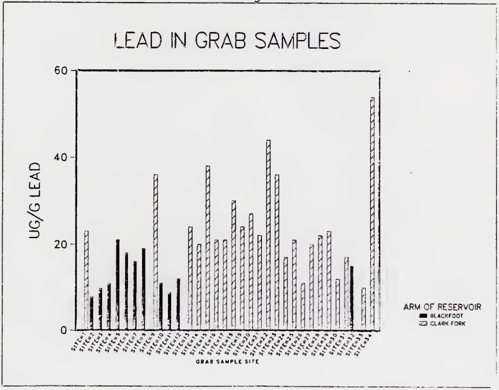


Figure G14

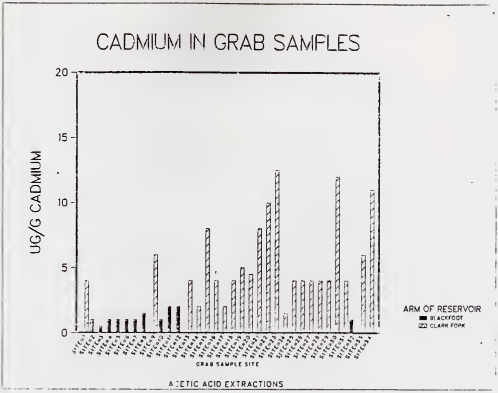
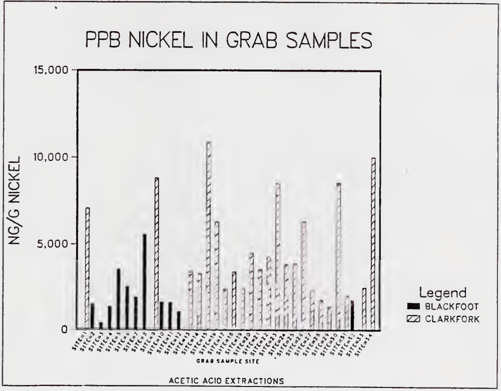


Figure G15



Histograms of Metals in the Pore Water of Grab Samples

Figure G16

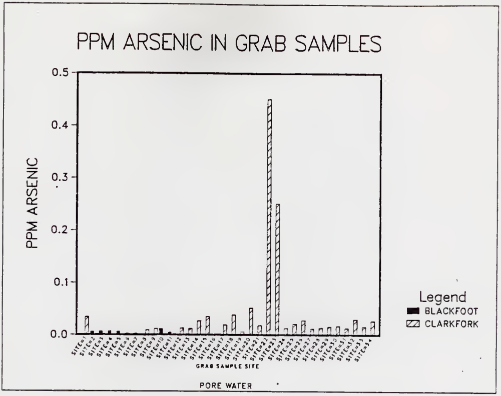
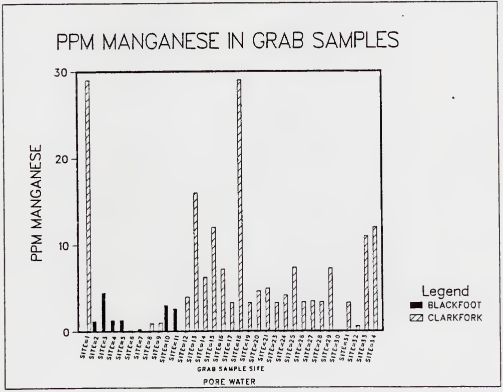


Figure G17



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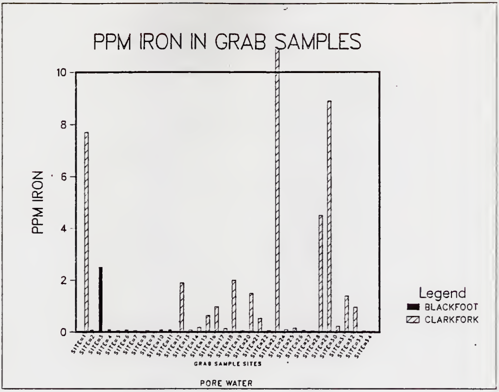


Figure G19

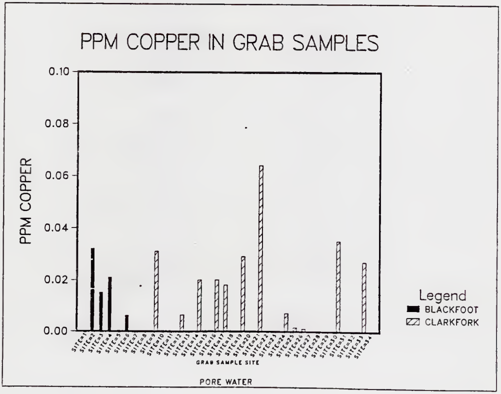


Figure G20

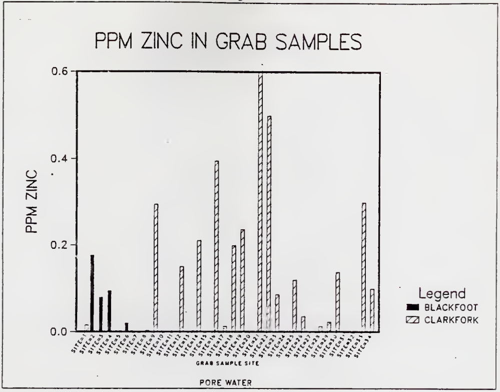


Figure G21

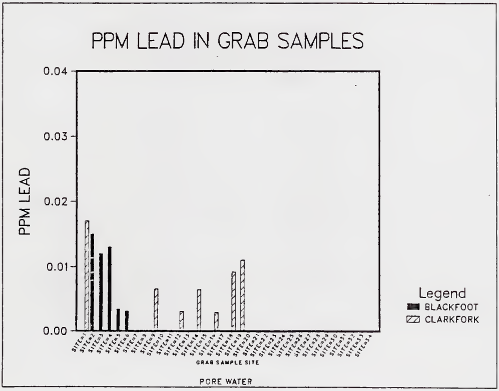
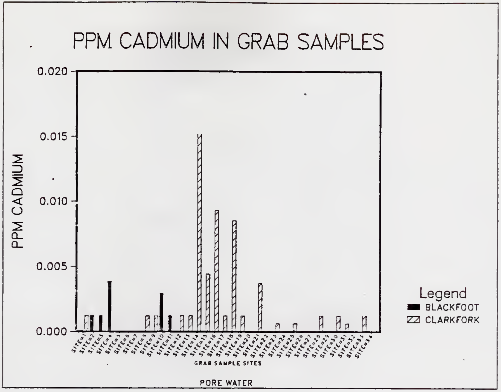


Figure G22


PPM CADMIUM IN GRAB SAMPLES
0.020
0.015
0.010
0.005
0.000
PPM CADMIUM
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SITE=2
SITE=3
SITE=4
SITE=5
SITE=6
SITE=7
SITE=8
SITE=9
SITE=10
SITE=11
SITE=12
SITE=13
SITE=14
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SITE=25
SITE=26
SITE=27
SITE=28
SITE=29
SITE=30
SITE=31
SITE=32
SITE=33
SITE=34
GRAB SAMPLE SITES
Legend
■ BLACKFOOT
▨ CLARKFORK
PORE WATER

Relative Percentage of
Metals in Different Fractions
of Grab Samples

Figure G23

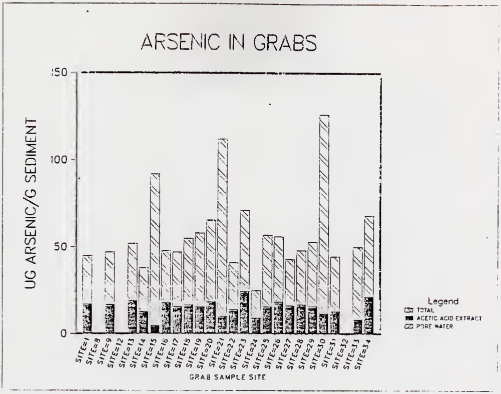


Figure G24

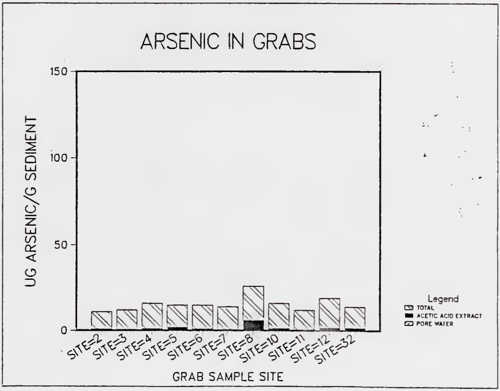


Figure G25

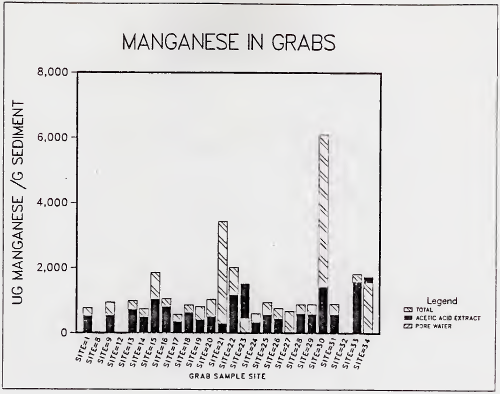
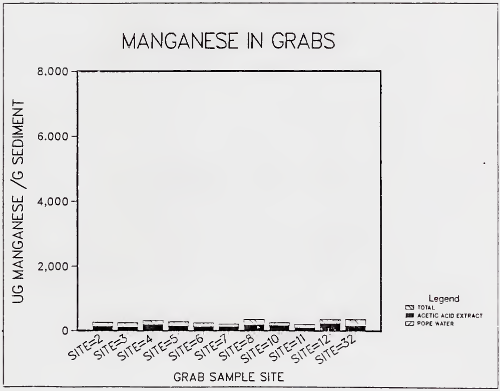


Figure G26



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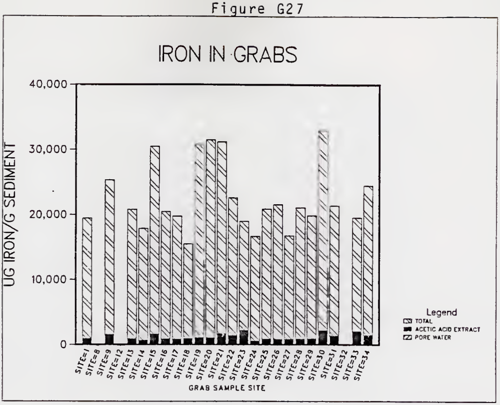

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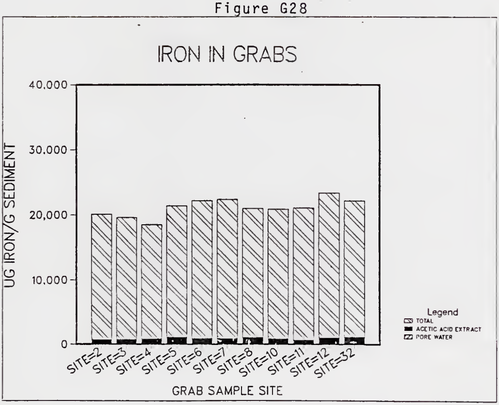


Figure G29

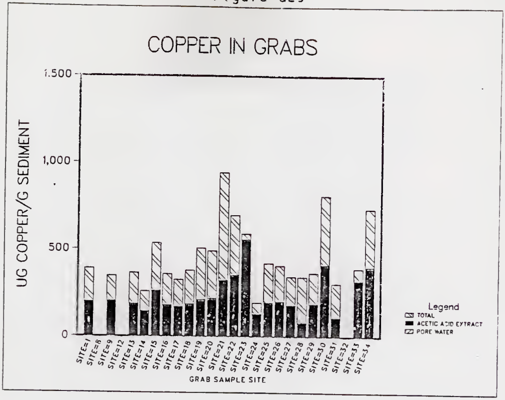


Figure G30

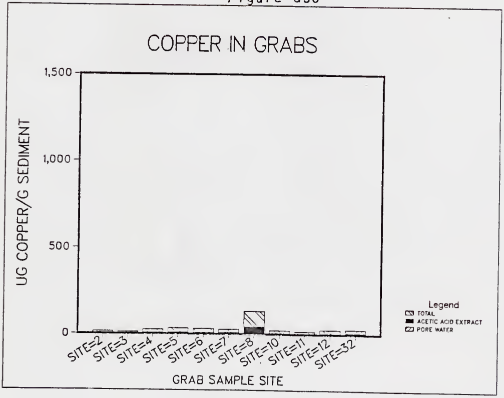
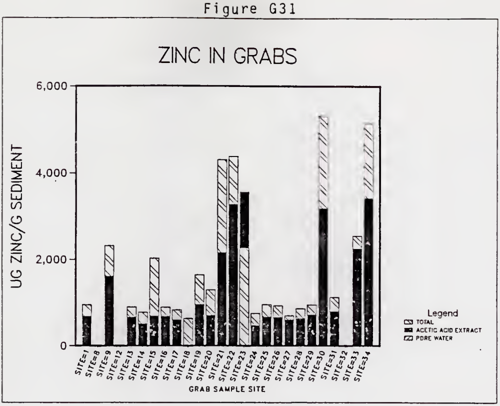


Figure G31



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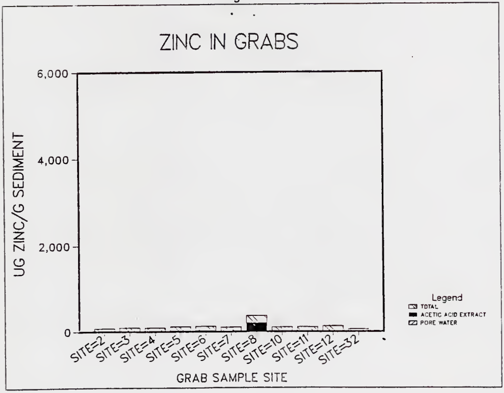

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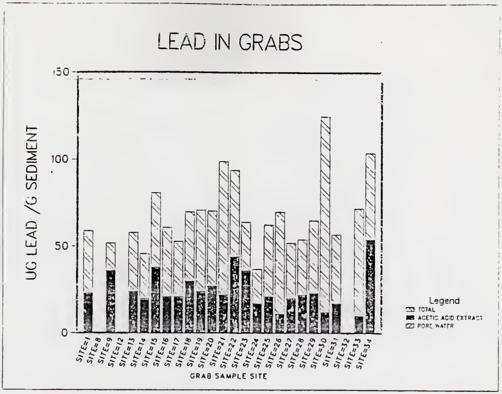

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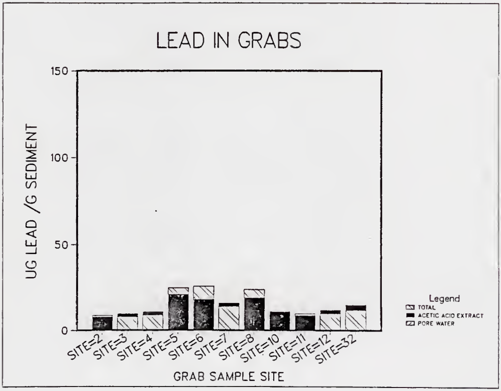
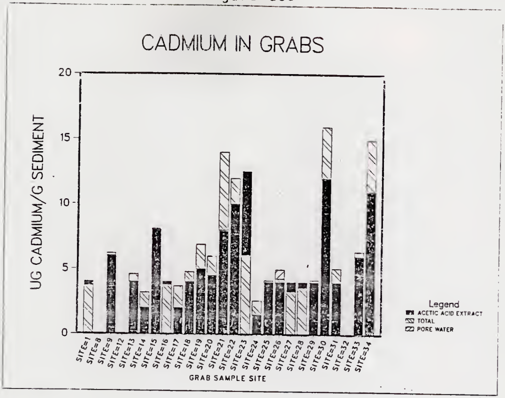


Figure G35



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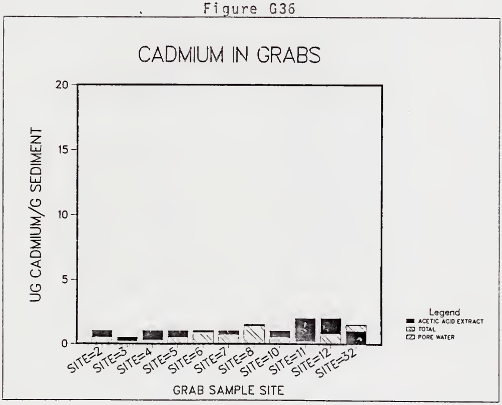


Histograms of Total Metal in Cores

Figure G37

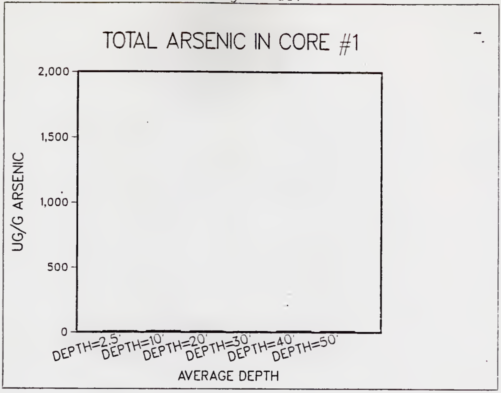


FIGURE G38

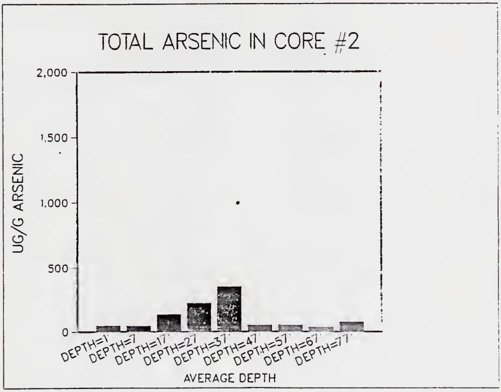


Figure G39

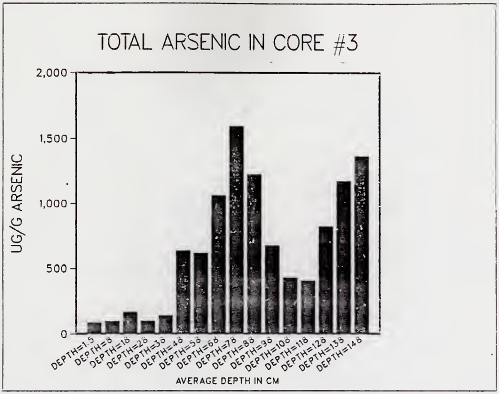


Figure G40

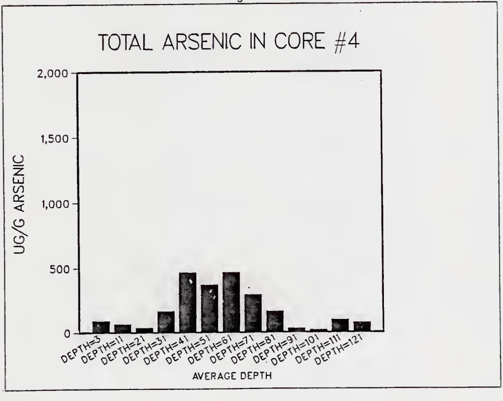
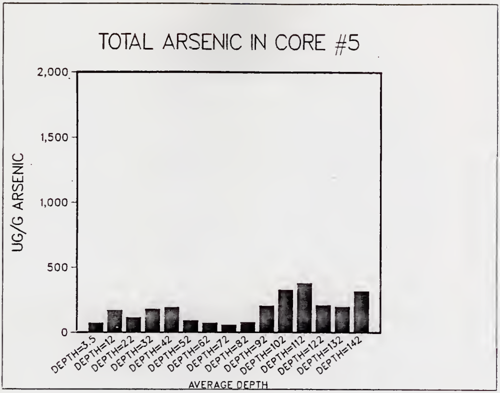


Figure G41



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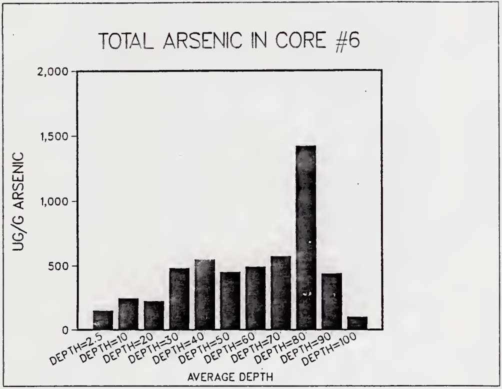

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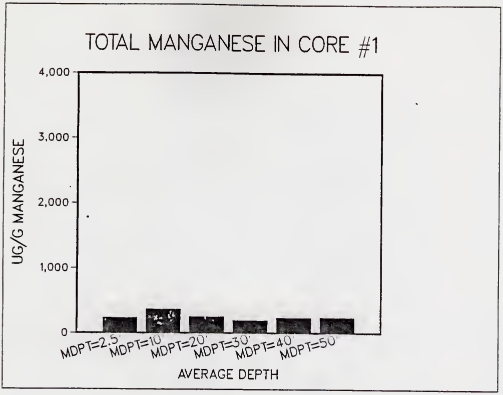

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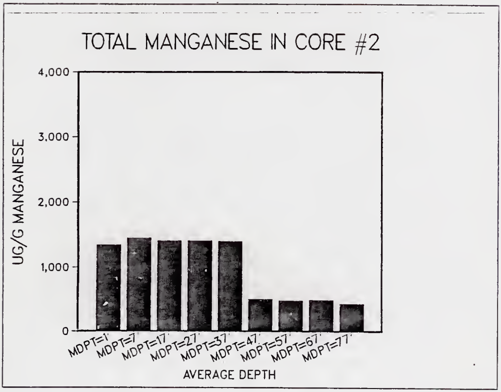

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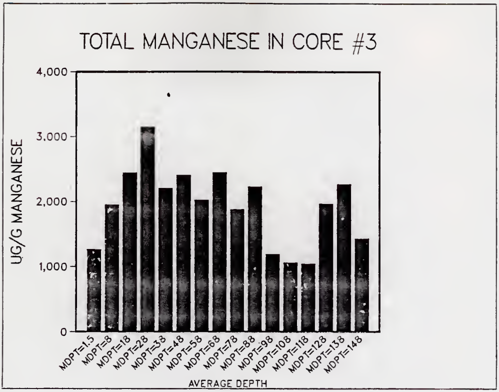

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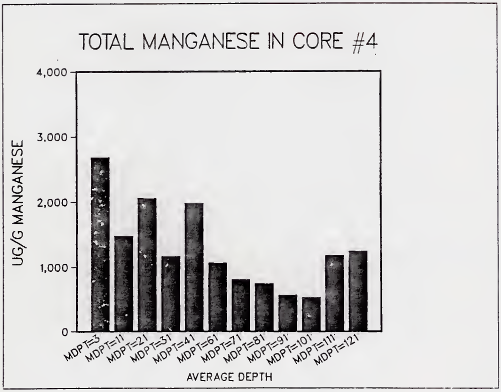
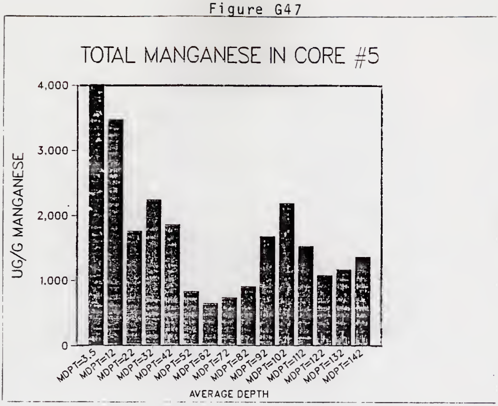


Figure G47



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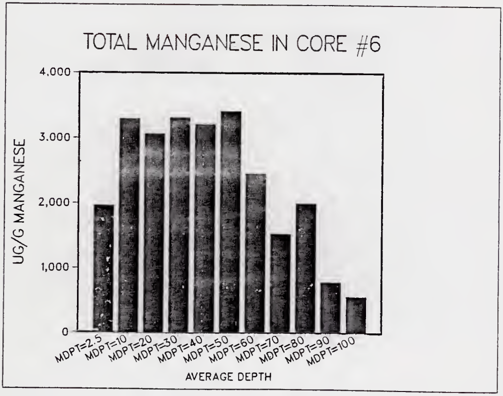


Figure G49

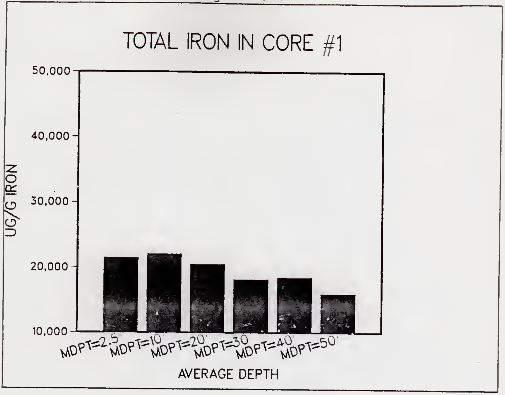


Figure G50

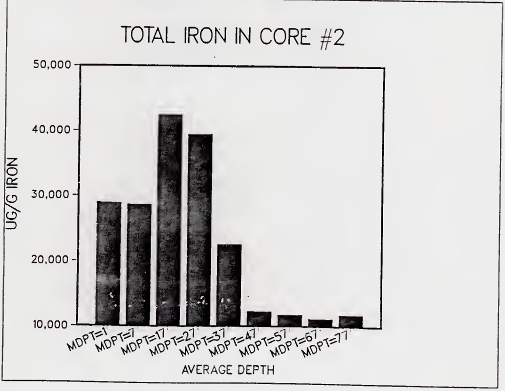
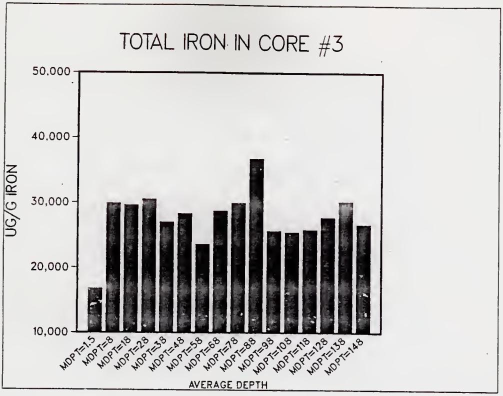


Figure G51



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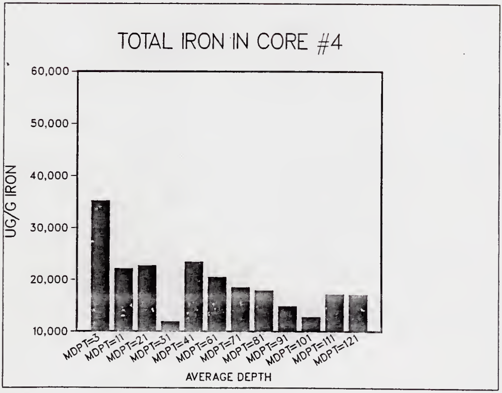

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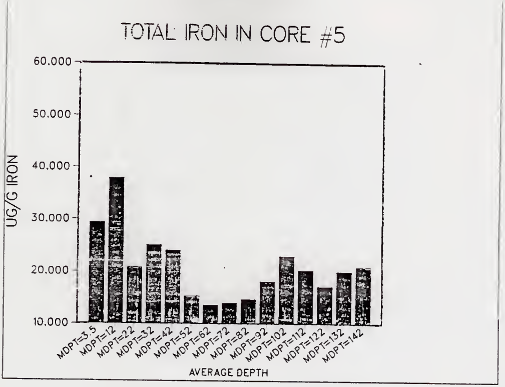
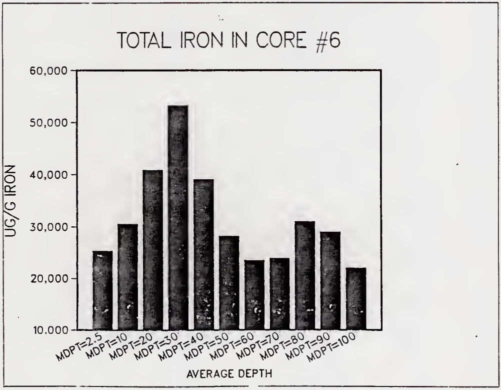


Figure G54



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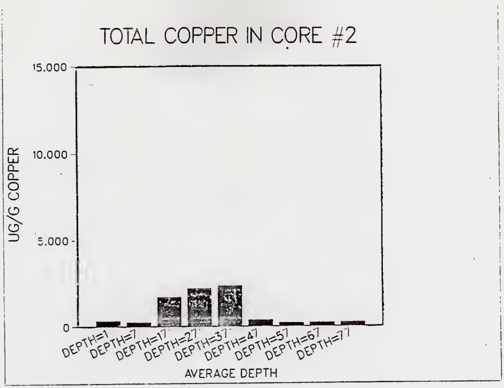


Figure G56

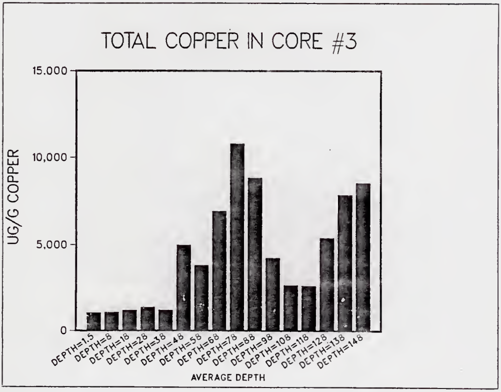


Figure G57

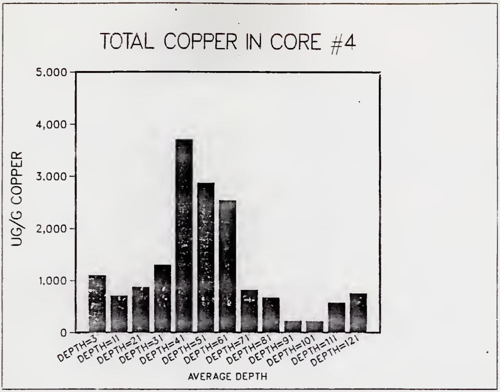


Figure G58

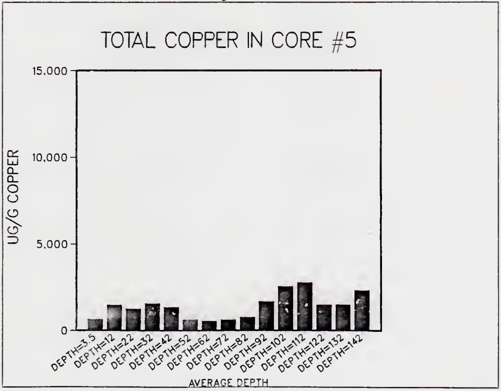


Figure G59

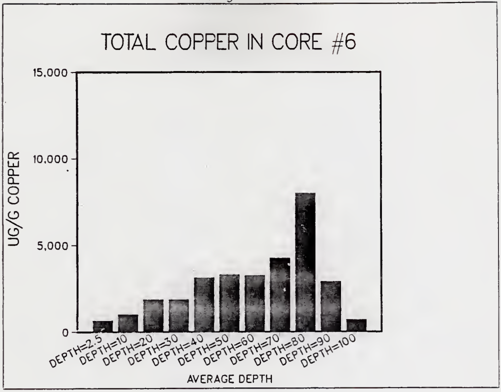


Figure G60

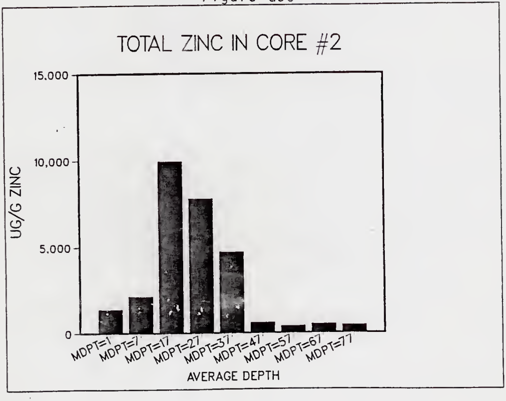


Figure G61

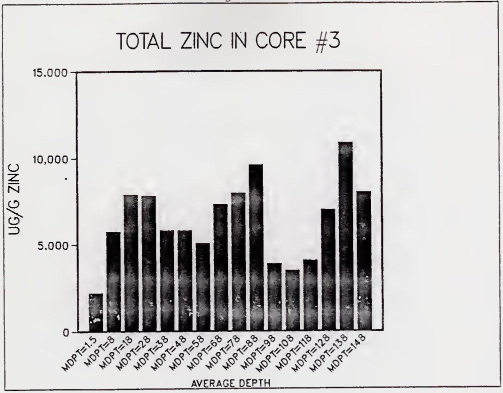


Figure G62

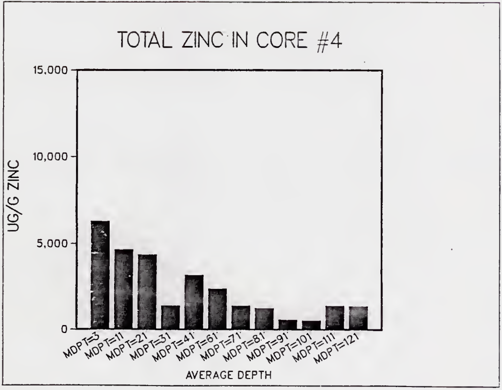
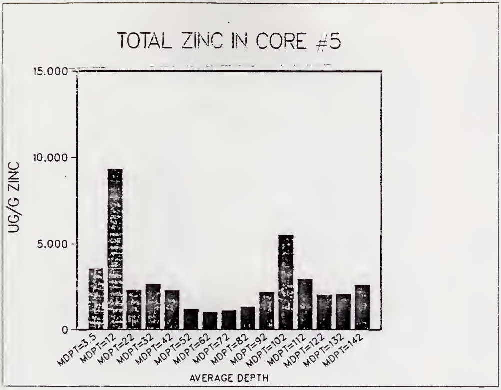


Figure G63



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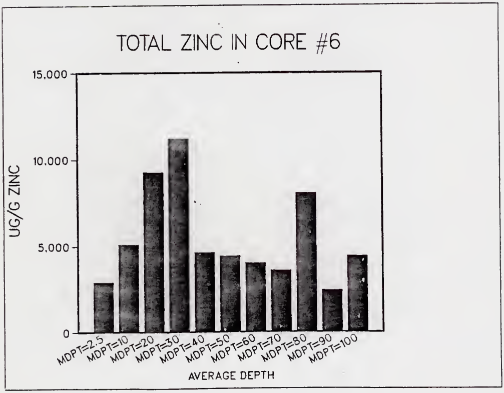

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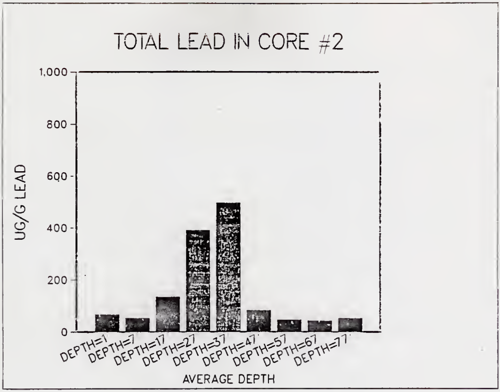

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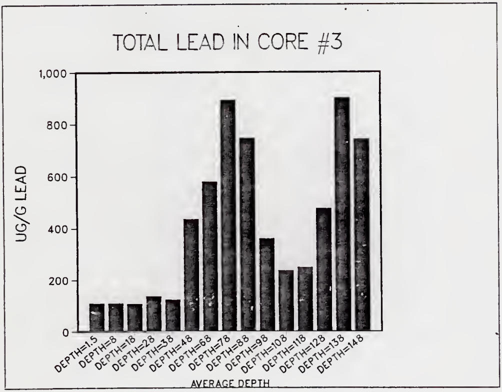
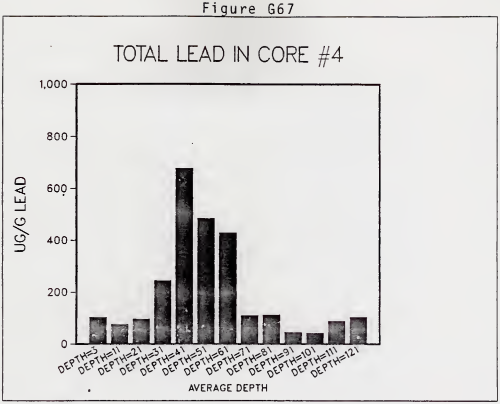


Figure G67



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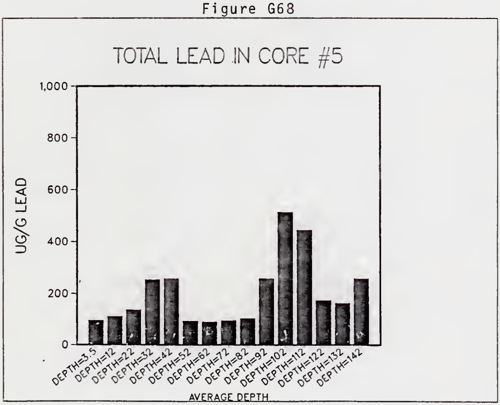


Figure G69

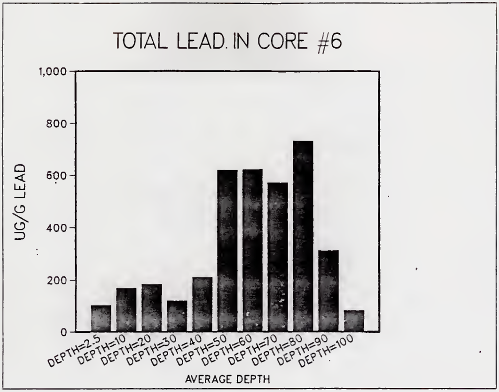
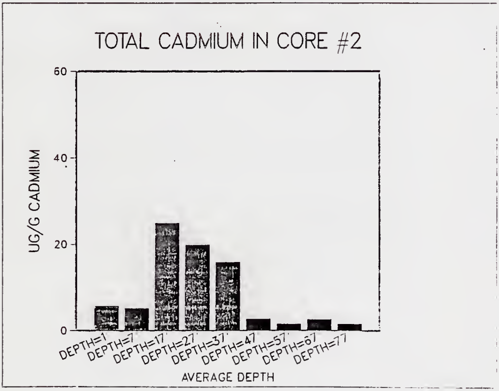


Figure G70



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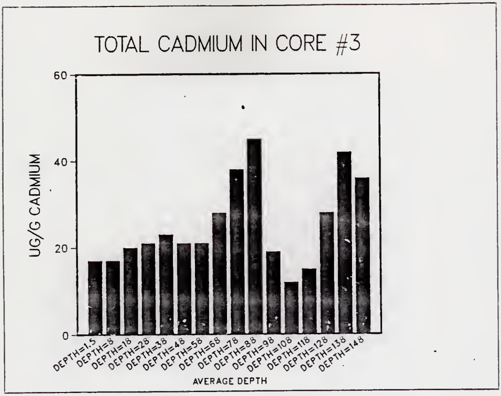

Figure 72